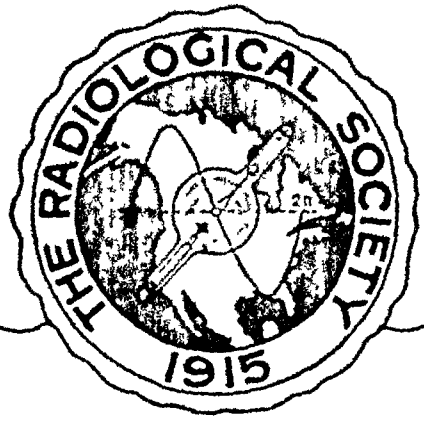
RADIOLOGY

MONTHLY JOURNAL DEVOTED TO CLINICAL RADIOLOGY AND ALLIED SCIENCES

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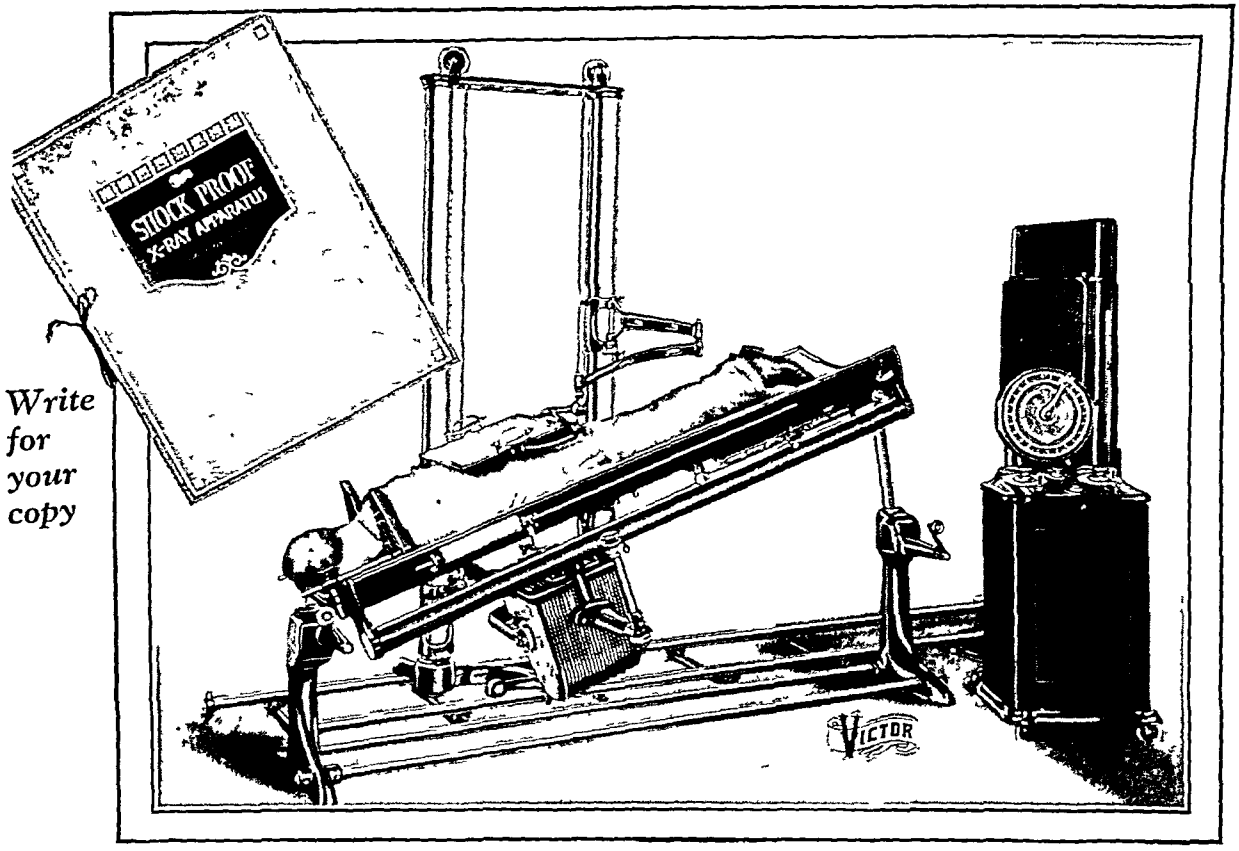
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THE PLACE OF X-RAY CRYSTALLOGRAPHY IN THE DEVELOPMENT OF MODERN SCIENCE

By J. D. BERNAL, PH.D., Mineralogical Laboratories, CAMBRIDGE, ENGLAND

VON LAUE'S discovery of the diffraction of X-rays by crystals effectively provided science with a new eye with which to see the ultimate arrangement of the nuclei and electrons of solid matter. It is true that X-ray analysis does not show atoms and electrons to the eye in the way that a microscope does; the process of interpretation is more complicated, but it is essentially analogous. In an ordinary optical instrument the interference of rays from luminous points is used to build up the optical image by means of a lens system. In X-ray analysis the interference pattern is taken and interpreted mathematically instead of optically to give the nature of the object observed, so that it is just one step farther removed from our inherited mechanism for appreciating the external world.

Now we have had this new eye only seventeen years, and although it has shown many marvellous things and enabled us to build for the first time a picture of the intimate structure of solid matter, we cannot believe that it has more than begun to be used. Many more important discoveries are bound to follow from it, and it has still to find its place as an essential instrument in every branch of scientific research. The object of this article is to point out what can already be seen of its possibilities and how it is likely to affect science in the near future.

THE THREE FORMS OF INFORMATION FROM X-RAY DIFFRACTION

Apart from the knowledge given on the nature of X-rays—which was of such critical importance in the discovery of atomic numbers and in the verification of Bohr's quantum theory of radiation—the diffraction of X-rays by crystals yields information about three grades of fine structure of matter. Ultimately the diffraction of X-rays is due to the interaction of the radiation with the electrons in the atoms of matter, and so the deepest information it can give is on the position of the electrons in the individual atoms, or, more correctly, information as to the average distribution of density of negative electricity. Here it is most closely related to pure physics and leads to the possibility of the complete description of the state of any piece of matter. But without going nearly so deeply, X-rays can show the position of the maxima of electrical density, that is, the position of each kind of atom, in a regular crystalline structure. It is in this field that the chief work of X-ray crystallography has been done. It is faced with the extensive problem of determining all the different possible types of atomic arrangement in solid substances, which has such a clear bearing on chemistry. Besides these two types of information, the diffrac-

tion patterns of crystals may be used as in ordinary crystallography to fix the nature and orientation of the minute crystals which go to build up common substances, with the advantage that there is no limitation to the substances which can be examined in this way, and a means is provided for analyzing all the textures of natural and artificial products. This is the type of information which links X-ray crystallography to biology on the one hand and technology on the other. The three types of information are not independent; strictly, the physical description underlies the others, but pending such complete description they have their immediate uses and we will treat their scope and possibilities separately.

X-RAY DIFFRACTION AND ATOMIC PHYSICS

So far as we know, the determination of the quantum numbers of every electron, which includes the allocation of that electron to a particular atom or group of atoms, gives the most complete picture of the state of matter that is available to us. Up to the present this complete description has been confined to single atoms in gases, to simple molecules, and to ionic crystals of simple types, such as the sodium chloride type, and here evidence from X-ray diffraction cannot stand alone but must be combined with the deductions of theoretical physics and the data of spectra in the ultra-violet, visible, and infra-red fields. What the X-rays give are the so-called F curves, which are measures of the internal interference of electrons in the same atom, and from which the radial distribution of the electricity in the atom can be calculated and used to check deductions made from other grounds. Unfortunately, X-rays are least sensitive to variations in the outer regions of the atom, which are the most important for the optical, magnetic, and chemical properties of the substance. But the exact determination of F curves is only beginning and it would be unwise to put any limitations on their possibilities. The great advantage the X-ray methods of examination have against the spectral is that they give information as to the ground or lowest energy states of the atoms, whereas the other methods necessarily deal with excited atoms and only inferentially with atoms in their normal state. This is particularly important in the case of metals where the state of a metal examined spectrally may be very different from what it is in the solid.[1]

STRUCTURAL CRYSTALLOGRAPHY

The determination of atomic positions in crystals is rightly considered the chief function of X-ray crystallography. The methods for doing this have been gradually perfected, particularly through the work of W. H. Bragg and his school, until they can deal satisfactorily with crystals of low symmetry and with a number of different atoms. The chief difficulty has been that all determinations of atomic positions must be indirect. It has, up until now, proved impossible to determine atomic positions by direct calculation from the intensities of diffracted beams of X-rays. The inverse process is, however, straightforward: from a known distribution of atoms it is possible to calculate exactly these intensities, and the problem reduces itself to finding by any means whatever a plausible structure and then establishing it accurately by means of numerical correspondences between observed and calculated intensities. Thus it happens that, although it is quite possible that the structure of an examined crystal cannot be determined at all, its determination, when it is carried out with sufficient care, can be relied on to give the exact positions of the atoms.

[1] For instance, Pd has a spectral S state, which, if preserved in the metal, would render it diamagnetic, whereas it is in fact paramagnetic.

THE IMPORTANCE OF CRYSTAL STRUCTURE TO PHYSICS

Very naturally the determination of a great number of structures has had to be carried out before their full importance to the physicist and chemist could be realized. To the physicist who is concerned with studying in detail the properties of a single substance, the relative positions of the atomic centers—which we designate as the structure—is important as the basic framework for any deduction of properties. It is not complete: that would require a description of the electrons and their quantum numbers themselves, but it is the minimum basis which must find a place in every formula expressing a physical property of the substance. The properties of substances may be divided into three types: those independent of structure, because they depend only on the properties of the individual atoms, such as the absorptive power for X-rays; those which depend on structure but are chiefly concerned with the immediate neighborhood of atoms in the structure, such as density, elastic constants, optical and magnetic properties, etc., and those which depend on the perfection or imperfection of the crystalline nature of the substance, such as plastic deformation, electrical conductivity, etc. It is the second group of properties that the structure determined by X-rays has been most useful in elucidating, but the third group has also yielded not so much to the X-ray determination of structure as to the determination of texture, which will be dealt with later.

CRYSTAL CHEMISTRY

But the importance of crystal structures to the chemist is far greater than to the physicist. So far, chemistry has been essentially a science dealing with the gaseous and, in part, the liquid states of matter. In order to know anything at all about the nature of a solid the chemists had to decompose it into a liquid or a gaseous phase and infer from its behavior what its original state was. X-rays have given a means for the first time of determining the actual state of chemical combination in solids. The information they provide can now be used to build up a complete chemistry, in which the world of old chemistry is seen to occupy but one place in the general classification. So far, this is only a possibility: chemistry has yet to be re-written on the basis of structural evidence.

In the chemical examination of substances the first stage was the determination of the actual numerical proportions of the different atoms composing them; then, from the existence of isomers, there came gradually to be built up by inference the more elaborate structural formulæ. What the X-rays have done is to move the structural formulæ from the plane of hypothesis to that of measurement. So far, the function of X-rays and orthodox chemical methods have been roughly complementary. In the inorganic realm, and particularly in the metals and silicates, the comparative stability of the structures rendered the chemical analysis of them very difficult,[2] but X-rays, through the advantages of their good crystallization and the heavy atoms they contain, have been able to unravel their structures and reduce them to order. On the other hand, in organic chemistry with its separate molecules, its great possibilities of transformation, and the liquid state of so many of its compounds, chemistry had the first advantage, and so far X-ray work has been needed for the most part only to confirm the validity of the chemical formulæ of the molecules and to give the extra information of how they are attached together. But it

[2] At any rate, so far as structural formulæ were concerned.

can hardly stop there. We have here a definite way of actually measuring relative positions and distances of atoms apart, and we may confidently expect that not only will X-rays be used more and more to determine structural formulæ, but no structural formulæ will be accepted unless its validity has been attested by X-rays. The peculiar advantage the X-ray structures have over the formulæ of the chemists is that, being metrical, they give the possibility of explaining the properties of a substance quantitatively from its structure. This knits the physics and chemistry of substances closely together and points the way to the inverse process of being able—given certain properties—to predict and then to synthesize the substance that will have them.

So far, however, it is for systematic chemistry that X-ray methods have been most valuable. Of the immense variety of substances, the great majority—and all the most complex substances—are solid at ordinary temperatures, and though every liquid or gas has a corresponding solid phase, the reverse is by no means the case. Consequently the classification of solid substances covers nearly all the field of chemistry. The classification of solids as it stands at present is based on the older chemistry, on the results of crystal analysis, and on quantum mechanics in roughly equal proportions. The three fundamental ideas are the knowledge of the types of interatomic binding forces and the concepts of co-ordination and atomic diameter. The latter two were in the first place chemical ideas, but were given a precise form through X-ray crystallography, particularly through the work of the Braggs, Goldschmidt, and Pauling. Alone, they would furnish the basis for a formal geometrical classification. But for a natural classification, one which would group together substances according to their physical and chemical properties, it is necessary to invoke the nature of forces between atoms. These forces, metallic, homopolar, ionic and Van der Waals, derive from the old valences of the chemists and the forces of cohesion of the physicists, but only through quantum mechanics have they received a rational explanation in terms of electronic structure. The new system of classification depends on an intricate blending of these ideas. We first divide crystals into the general physical types, metallic, homopolar, adamantine, ionic, and molecular, according to the type of the chief force binding the crystal units together, the units being simple atoms or complex molecules or ions themselves held together by other forces. Inside this, the crystals fall into divisions on geometrical grounds based on their co-ordination, atomic diameters, etc., a process of classification of which, owing to the small number of substances examined, only the general lines can be seen. It is worth while examining the leading physical types to see how much of our knowledge of them is due to the study of their structure and how much information we may expect from it in the future.

THE NATURE OF THE METALLIC STATE

It is astonishing, considering their simplicity and the extent to which they have been studied, how little was known up to a few years ago of the inner nature or even of the chemical composition of metals and their alloys. Thermal and micrographic analysis had enabled the equilibrium diagram to be determined for a number of systems, but what each phase in the diagram stood for, the meaning of the various compounds and solid solutions which seemed to have no relation at all with the ordinary laws of chemistry, was completely obscure. So also was the relation of the composition of metals to their physical properties. With the X-rays came a new era in the study of metals. In a single paper Hull determined the structure

of nearly all the common metals and showed the extremely simple way in which their atoms were fitted together in a close packing, which was afterwards to prove the characteristic structure property of metals. Since then, the field of alloys has also yielded its secrets. Very considerable work has been done on pure metals, alloys, and alloy systems, particularly by Westgren and his school. The characteristic of a phase in the equilibrium diagram is seen to be a certain crystal structure and not in the ordinary sense a chemical compound. Its composition may not be fixed, because, owing to the extremely generalized attraction between metal atoms, any atom may be replaced by another (within certain limits of size and electronic configuration) without a change in the crystal structure. This is what gives intermetallic compounds a peculiar indefiniteness of chemical composition, while preserving fairly constant the physical properties which depend primarily on the crystal structure. At the moment, the laws of chemical combination of metals are just beginning to be found out and seem to depend more on geometrical and spatial considerations than on the chemical properties in the ordinary sense of the atoms concerned. This appears quite reasonable when we begin to see that what we are dealing with in the metal is not the atom as we see it in chemical compounds, stripped of its outer electrons as the ion, or sharing them with another in homopolar binding, but still holding them as an insecure outer shell, responsible at the same time for the mechanical cohesion of the similar atoms and for the electrical conductivity which can occur when they interchange electrons.[3]

But all this is only one side of what X-rays have done and promise to do for the study of metals. The mechanical properties of metals are of overwhelming technical importance and considerable theoretical interest, and X-rays have for the first time enabled us to see what is going on in a metal subjected to mechanical stress. The problem was a very complex one, and it was seen that the first simplification required was to deal, not with a confused mass of small crystals, but with single crystals, the manufacture of which was largely a by-product of X-ray methods. In single crystals the process of hardening by working or by alloying with small quantities of foreign metals has been followed simultaneously mechanically and by X-rays, the particular glide planes of the different metallic lattices and their differences of behavior have been experimentally mapped out, but the greater part of the task —the devising of an adequate theory based on fundamental physical concepts—has yet to be developed. The inspiration for it must come from the wave mechanics, but at every point X-ray analysis will be required to check it. Once we have suggested a theory, or even an approach to it, metallurgy will cease to be what it has always been in the past—a thoroughly empirical science requiring an enormous amount of haphazard experimentation to find a single valuable technical process—and become a branch of physics, having the practical advantage of being able to reveal, by means of calculations, the exact composition and treatment required to make an alloy having any desired properties.

ADAMANTINE COMPOUNDS

Closely related to metals and forming the bridge between them and ionic chemical compounds are the compounds called adamantine or homopolar, which occur in nature chiefly as the ores of metals, and in industry as slags. Of these compounds of metals with atoms of the carbon, phosphorus, and sulphur groups, the chief bind-

[3] This seems to hold for true metals, iron, copper, etc., and their alloys with each other, but in case of alloys of the tin or antimony groups, etc., there seems some evidence for homopolar bonds and even for ions.

ing forces are homopolar, the whole crystal forming one large molecule. As in the case of metals, their chemistry was very obscure, as the compounds were indefinite in composition and no ordinary valence relations seemed to hold. The X-ray study of this group has not yet proceeded very far, but already it seems to show that the compounds are reducible to a few leading types. Of these, the chief is the diamond—zinc blende structure—in which every atom is bound to four neighbors by homopolar bonds. This is the basis of the structure of a large number of sulphides, carbides, etc., containing a roughly equal number of metallic and non-metallic atoms. The next simplest is the nickel arsenide type, of which each atom is bound to six others with homopolar bonds. This, or structures deriving from it, accounts for a great number of simple and complex arsenides, antimonides, and stannides. Where the non-metallic atoms are in excess they hold together by homopolar bonds and form molecular units, leading to structures of the pyrites and calcium carbide type. In this field, which forms the bridge between metallurgy and mineralogy, X-rays have an important part to play. On the mineralogical side, for instance, as the substances are for the most part opaque, the X-rays may take the determinative character that optical methods have in petrology. On the theoretical side the transition from metallic to the non-metallic study is of extreme interest, for it is in this region that such phenomena as photo-electric conductivity and high frequency rectification are found to occur.

IONIC COMPOUNDS

The field of ionic substances is the classical region of X-ray crystallography; the typical ionic crystal, rocksalt, was the first to have its structure determined, and it is in the more complex ionic crystals, particularly the silicates, that X-ray analysis has scored its greatest triumphs. In this field theory and experiment adequately supplement each other. The forces holding together ionic crystals, being for the most part simple Coulomb attraction, are naturally the first to be amenable to calculation, and the repulsive forces which balance them can be described empirically as due to semi-rigid atoms of definite radius or theoretically by a resisting force proportional to high powers of the inter-nuclear distance. The crystal analyses of W. L. Bragg for more complex compounds and of Goldschmidt for the simpler ones laid the empirical basis for a systematic classification of ionic compounds. To a first approximation it can be based on the concept of atomic diameter and co-ordination numbers, the latter depending only on the ratio between the diameter of the central ion and that of the ions which surround it. Pauling has even generalized these conceptions into rules which can be used for predicting the structure of compounds of known composition and even predicting which will be the stable compounds in mixtures of metallic oxides. The idea of a measurable atomic diameter is bound to have immense repercussions in inorganic chemistry, particularly the picture of the large, easily polarizable negative ions and the small, effectively polarizing positive ones. It explains, for instance, the formation of complex ions by elements of the fourth, fifth, sixth, and seventh groups and the great preponderance of ions of the type AX_4 among them.

The main divisions of ionic compounds have also become clear. First come simple oxides and halides of the general type $A_m X_n$, which are further subdivided according to the co-ordination number of the negative to the positive ions, varying from 8–4. Next we have complex oxides and halides in which a number of positive ions varying in charge and diameter share an

equivalent number of negative ions. The great bulk of the silicates fall into this class and their complexity is seen to be largely a purely geometric one, the problem of a silicate structure being first to see that each positive ion has its proper co-ordination number of oxygen atoms, beginning with the smallest and most positive, which is generally silicon, and subsequently that each oxygen ion is surrounded by a number of positive ions, so that the total induced charge on it is as nearly as possible —2. In any structure satisfying these requirements there is still considerable freedom of choice of the metal ions, and X-ray analysis has for the first time explained the nature of isomorphous substitution in ionic compounds. In the first place, ions of the same charge and approximately the same diameter are virtually interchangeable from the point of view of structure; such, for instance, is the group Mg^{++} Fe^{++} Ni^{++} Co^{++} Mn^{++}. But size is more important than charge, and ions of different charges and similar sizes are interchangeable if compensatory changes take place elsewhere in the structure; such, for instance, as the Ca^{++} Al^{+++} $Na^{+}Si^{++++}$ substitution in the felspars. The chemical constitution of silicate minerals has been a region of immense speculation and formula-building. X-ray analysis has already introduced an extreme simplification and shown itself to be indispensable to the proper understanding of their nature.

After the complex oxides come the complex ionic compounds of which the commonest are the Oxy salts. Here the units are the ions of determinate form, such as sulphate, perchlorate, beryllofluoride, ammonium.[4] The types of crystal formed closely resemble those of the simple or complex oxides and halides, differing only in having in general a lower symmetry due to the substitution of the complex ion for the spherically symmetrical simple one. Beyond the complex ionic compounds come the co-ordination compounds, ionic compounds containing neutral but in general strongly polar molecules, such as water and ammonia. This field has been least explored by X-rays, but its most symmetrical members show how extraordinarily exact were the ideas which Werner enunciated about these compounds. The polar molecules cluster round the smallest and most highly charged ions[5] forming larger ions which build up crystals exactly as simple ions do. Already the general classification of inorganic salts is clear: it requires only expansion to cover the case of unsymmetrical and large complex ions such as perchlorates, silicotungstates, etc. It is, however, apparent that such ions will fall into two types—closed and open. The closed type consist of high-group atoms sharing oxygens between them, of which the simplest are the dichromates, but which may have the complexity of rings or even baskets, as in the silicotungstates. These ions still behave as simple ions in the crystal except in so far as their peculiar shape interferes with the symmetry in the crystal and in solution. In the other type, which is that of the silicates and probably a number of phosphates and similar salts, the linkage of high-group atoms through oxygens continues throughout the whole crystal. It may take the form of simple chains or ribbons, of plates or spatial lace-work. Such crystals are necessarily insoluble without decomposition and their physical properties depend almost entirely on the form of their ionic network, *e.g.*, fibers of asbestos, plates of mica, hardness of quartz, etc.

MOLECULAR AND ORGANIC COMPOUNDS

There is no doubt but that organic crystals furnish greater complexity and variety

[4] Whether the inner forces of these ions are homopolar or themselves ionic, probably varies from case to case, and there may be no real distinction between these two views. At any rate, there is none so far as the way they are built together to form the crystal is concerned.

[5] Their number seems to be determined by steric considerations rather than by those electronic rules proposed by Sidgwick.

ther case of molecular association is furnished by those so-called polymerized substances whose physical properties, particularly their mechanical properties and their lack of solubility, differ so markedly from their organic compounds. Here it is almost certain that the molecules are held together, not by electrically polar forces, but by homopolar linkages, so that one is really dealing with macro-molecules or open molecules of indefinite length in one, two, or three dimensions, exactly equivalent to the open ionic groups in the silicates and similarly associated with their physical properties. These different types of molecular binding are only roughly outlined as yet and simply point to a field of possible application of X-rays to organic chemistry. The complexity of molecules obviously makes it possible for all three types of binding to exist simultaneously in the same substance, and the task of X-ray analysis lies in the disentangling of these forces. Ultimately, also, X-rays will come to be used for the direct determination of structural formulæ. Up to the present they have been limited to verifying the tetrahedral valences of the aliphatic atom and the plane hexagonal character of the benzene ring. But in crystal analysis rapidity of advance depends on the number of structures already known and may consequently be expected to proceed with increasing acceleration, provided sufficient interest is felt in it in chemical circles. The knowledge of the exact metrical structure of an organic molecule is bound to have great importance, not only in structural chemistry, but in chemical transformations. The question, for instance, of steric hindrance will require a quantitative explanation, as also will many problems of catalysis. Already a connection has been shown to exist between the spacings of atoms in a metal catalyst and the type of reaction effected, and it seems plausible to suggest that for complex reactions the catalyst acts like the frame of a lace-worker, holding the complicated molecules in positions in which they can combine or decompose.

LIQUIDS AND COLLOIDS

X-ray methods, however, are not confined to the solid phases of organic compounds, but also extend to liquid and colloidal phases. The interference pattern of organic liquids depends chiefly on relative positions of atomic centers in the same molecule, and can be used to deduce them. Information is also given as to the mode of association of molecules in a liquid, with particularly interesting results in the case of solutions.[7] An even more partial method, applicable to liquids and even to vapors, is that of using electron waves instead of X-rays, as the former are more sensitive to light atoms, such as carbon and oxygen. For the colloidal state X-rays also yield important information. Simple dispersed colloids, metal oxides, etc., have been shown to be merely extremely small crystals. The miscellar colloids and gels seem to fall into two classes. In one case, as in the soap-like colloids, the colloid particles seem to consist of a number of molecules placed side by side in a condition intermediate between that of a crystal and that of a liquid and closely related to liquid crystals, whereas in other cases the colloid constituent is really a macro-molecule held together throughout by homopolar forces. If these linkages hold throughout the whole substance the fiber network forms a gel—if they are independent, a sol.

BIOLOGICAL STRUCTURES

Investigations of liquids and colloids bring X-ray methods definitely into the field of biochemistry, and already, particularly in

[7] Prins has shown, for instance, that in ionic solutions the ions form an approximately cubic lattice the interstices of which are filled with water molecules.

the determination of the cellulose structure, important results have been achieved. In many ways solid substances formed by biological action have greater regularity than when made in the laboratory. When mineral substances are deposited, particularly calcium carbonate or phosphate, it is nearly always in the form of single crystals or crystalline layers, but even when the substances are themselves complex or organic products regular crystallization seems more the rule than the exception. In the building of the cotton fiber, the cell deposits each day a layer of cellulose macro-molecules in parallel orientation to that deposited the previous day, thus making the single fiber approximately a single crystal. Similar relations hold for the building up of animal fibers, such as hair and horn, etc. Peculiar interest attaches to those natural products which have crystalline or amorphous forms according to their mechanical state, of which the first to be completely explained by means of X-rays has been rubber. Here the spirally curled molecules remain disordered until the rubber is stretched, when, by straightening out, they link side by side to form regular crystals which break down again on contraction. It is in this sort of behavior that the explanation for contractile animal fibers may be found, and there is certain evidence that muscular activity depends on the existence of crystals formed in each contraction. X-ray analysis, which has the advantage of being able to be applied *in vivo*, is bound to become an important auxiliary method in the study of biological processes, particularly if a technic can be developed of short exposures, enabling the existence of momentarily produced substances to be detected.

TEXTURE

It is only in exceptional cases that a substance is found in Nature in the form of single crystals. Most common substances are aggregates of large numbers of minute crystals. The size of these crystals and the way in which they fit together to build up the substance have been conveniently termed its texture. The importance of texture has always been realized, as the mechanical properties of matter in gross depend on it, particularly those directed properties we know as "grain." But except where the texture was very coarse it remained completely obscure until elucidated by X-rays. The X-ray analysis of texture depends on the superposition of the innumerable diffraction patterns due to each individual crystal in the substance, and can give information of four kinds: as to the mean size, the shape, the statistical orientation, and the state of strain of the crystals.

The full meaning of texture of a substance can be revealed only by combining an understanding of its mode of origin and its behavior under different treatments with the interpretation of X-ray diffraction patterns taken at every stage. This is an intricate but fascinating mode of study. Up to now it has been applied only to metals and textile fibers, but its field of application is much greater, for it holds the key to many technological, biological, and even geological problems. Nor will it in the future be limited to mere analysis and description of textures already existing, but will go forward to the synthetic constructure of textures having interesting or useful properties.

PRACTICAL APPLICATIONS

I have attempted to show in the preceding paragraphs the place that X-rays have already taken in the elucidation of fundamental physical and chemical problems, and the still more fundamental place they are likely to take in the future. But besides this so-to-speak pure application of X-rays, the X-ray technic has a range of simply instrumental application which is already recog-

nized in a few fields but is likely to become universal. These applications are essentially practical rather than academic and could affect every industry without exception. In the first place, an X-ray diffraction pattern of a substance is characteristic of its internal structure and, therefore, without interpretation can be used as a standard of structure and consequently of quality. It detects immediately two important types of variation —alteration of chemical constitution or adulteration by foreign chemicals on the one hand, and grain size, orientation of particles, and internal strain on the other. Thus, ultimately, X-ray apparatus will have to take its place in every factory as a testing instrument for raw materials and finished products. The fields where it has already been used for these purposes are, firstly, in metallurgy in connection with rolled sheets, wires, etc., and in the process of tempering.[8] In textile industries X-rays have been used to detect the parallelism of fibers of cotton, artificial silk, etc., which is closely connected with their strength. In ceramics also X-rays have been used for testing varieties of china clay and the proper firing of porcelains. It is very difficult to think of any industry to which it cannot be applied with advantage. In mining, for instance, the actual character of the different constituents in massive ores can be very easily determined by its help, and it is bound to have a bearing on the process of smelting. In a general way the X-ray methods can always be relied on to give further information and deeper understanding of practically every process which heretofore has been carried out by empirical and traditional methods, and ultimately to lead to its improvement.

It has already shown its value as an auxiliary method of chemical analysis. Every crystalline substance has its characteristic X-ray pattern which would enable it to be immediately recognized as soon as a sufficient number of substances have been examined as standards. The particular value of the X-ray method lies, however, in its discrimination between the existence of an impurity in the form of a foreign crystalline phase or as a solid solution, in the former case giving rise to extra lines, and in the latter to a shift in the lines of the pure substance, the amount of which is a measure of the quantity of impurity present. Another application that will undoubtedly be developed is X-ray petrology, which, if it does not supersede optical petrology, will be a very useful complementary method wherever the latter does not give sufficiently determinate information.

DEVELOPMENT AND ORGANIZATION

In the foregoing I have tried to show the importance and the possibilities of X-ray analysis, but these possibilities cannot be realized to the full unless the study of the subject is pursued on a sufficient scale and in a sufficiently co-ordinated manner, and at the same time find its proper place in relation to other subjects. At the present time I think it can fairly be said that it has passed the period of pioneer investigation which must necessarily be left to individual genius and initiative and is not susceptible to any organization. For its continued growth this stage must give way to one in which there is a centered and organized attack on the problems involved and where the isolated solutions of particular problems are followed up by a systematic exploration of the whole field. For this to be possible it is in the first place necessary that adequately trained workers be available in sufficient numbers, and this implies the introduction of the new crystallography as a regular part of university and technical college training. At the same time, the subject cannot flourish

[8] The characteristic interstitial carbides of steel, for instance, are shown to form in thin layers on the surface, depending on the method of heat treatment and consequently forming a check on it.

unless the assistance that it can give to other branches of knowledge is more fully realized and consequently its teaching must be arranged in relation to the physics and chemistry with which it is so closely connected. There should be no question of setting up a new and separate subject of X-ray crystallography. Though its object in the first place must always be to deepen our knowledge of the structure of matter, its chief utility will always be the fundamental assistance it gives to the process of knitting together all physical science into an harmonious whole.

THE RELATION OF DIETARY TO THE EFFECTS OF LARGE AMOUNTS OF X-RAYS ON THE ORGANISM[1]

By LOUIS H. JORSTAD, M.D., and EDWIN C. ERNST, M.D.

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IN EARLIER work dating from 1926, we devised a means whereby we could determine through biological tests on animals the nature of the action of graded doses of X-ray energy on the organism (1). We noted early in this work that the initial dose of X-ray energy produced a gastro-intestinal disturbance in animals, very similar to the gastro-intestinal disturbances which we obtained by the addition of increased quantities of Vitamin B to the organism. In work preceding this we had demonstrated that the *Bacterium tumefaciens* in the early culture produced Vitamin B when grown in potato decoction (2). Rats given a ration deficient in Vitamin B showed no signs of Vitamin B deficiency when the early culture of *Bacterium tumefaciens* was added to the ration; neither did they show toxic symptoms. The weight curves of these animals corresponded to the weight curves of animals which were given relatively small dosages of X-rays (3). When the *Bacterium tumefaciens* is allowed to overgrow the medium in which it has been transplanted, the time interval necessary being fifteen days or more, the result of our feeding experiments showed that this culture imparted Vitamin A to the organism when added to a Vitamin-A-deficient diet (4). We found also that by increasing the dosages of X-ray, the larger dosages imparted Vitamin A to the organism (5).

At that early time these data were obtained by an analysis of the weight curves of animals on Vitamin-A-deficient diets. The X-ray energy was administered in the form of general body doses. In later studies it was interesting to note that by inducing a third degree erythema 1 cm. in diameter on the posterior surface of the neck of a rat, the animal was protected against a vitamin deficiency on a Vitamin-A-deficient diet for a period of ninety days. Control animals in the same series in which this was not induced, showed definite signs of Vitamin-A-deficiency within thirty days.

Thus, the process taking place in the culture of *Bacterium tumefaciens* may be compared with that which takes place in the animal body to which X-rays are administered. As the culture overgrows the medium, the organisms degenerate, and as this process becomes more complete, more of the fat-soluble constituents are liberated from the protoplasm. In the early culture, before degenerative processes have set in, the water-soluble constituents are liberated in the medium.

Thus, with the X-rays, the smaller doses cause the body cells to liberate the water-soluble constituents in which are contained the cell stimuli. With the larger doses, death of the cell occurs, or, at least, a partial destruction of its protoplasm takes place and this causes the liberation of the fat-soluble constituents, of which Vitamin A is a part. If this occurs in a local area of the body, the remainder of the body will be supplied with these constituents from this area for a period of time. If the process takes place throughout the whole body, the fat-soluble substances must be supplied to the animal body from without or death of the animal will result.

In working with lipoid solvents, such as coal tar, Mazola oil, mineral oil, etc., we have noted that upon the introduction of the

[1]Read by Louis H. Jorstad, M.D., before the Radiological Society of North America at the Fifteenth Annual Meeting, at Toronto, Dec. 2-6, 1929.

solvent into the subcutaneous tissue, hyalinization of the tissue occurs about the mass of solvent (6). When the solvent is applied to the skin we obtain a keratosis (7). In previous papers we have discussed the relationship of keratosis to hyalinization and the relationship of both of these to hyperplasia of tissue. They become important from the standpoint of hyperplasia in that our studies of previous date have shown that the hyperplasia or increased cell activity of the fixed tissue type is due to the presence of a stimulus in amount above that of normal in body tissue. The increased amount of this stimulus can be brought about in two ways: by a direct addition of the stimulus to the tissue, as, for instance, the addition of Vitamin B or embryonic tissue to a dietary, by the application of a relatively small amount of X-ray to the body, or by adding embryonic or malignant tissue juice to a tissue culture. The most striking, or, at least, lasting, evidence of the presence of cell stimulation in the body is found, however, when we have removed a certain quantity of fat-soluble vitamins from a localized area of tissue. The fat-soluble vitamins may be removed by any lipoid solvent or they may be removed from a more local area of tissue by the giving of a larger dose of X-ray. The striking pathological picture in either of these conditions is that of hyalinization, and we have come to the conclusion that a hyalinized tissue is one which has lost all or part of its fat-soluble vitamins. Hyperplasia in these conditions occurs in areas adjacent to hyalinized areas. In other words, the hyalinized tissue is depleting slowly the fat-soluble vitamins from the non-hyalinized tissue, and if there are cellular areas in this zone they will undergo hyperplasia, while if the conditions are proper for such a change to take place, actual cancer may develop. This is seen clearly in X-ray erythemas. The epithelium adjacent to the hyalinized tissue produced by the action of the X-ray undergoes hyperplasia, but more marked hyperplasia occurs in the hair follicles, the X-ray having hyalinized the tissue surrounding them, the follicles themselves not being destroyed with the same amount of X-ray energy.

Thus, these studies have led us to believe that the more important of these two substances is the fat-soluble constituent of the tissue. The greater importance of this substance may be accounted for by the fact that the stimulating substance is water-soluble. This has been shown by dialysis and other biological tests (7). Thus, it can be considered as a more evanescent substance, one that interchanges frequently throughout the life of the animal. But the fat-soluble substance is more stable in character and thus is less easily removed. By gradually increasing the general body dosage of X-rays given to these animals, we noted that the protective action of these fat-soluble vitamins became less marked, and with a dose of 125 ma.-min., or 155 r, administered twice a week, the protective action of the diet was not obtained until we had increased the Vitamin A in our general diet to from 3 to 5 per cent above the normal content of a well-balanced ration (8). Thus, these observations tend to support the view that X-rays act to cause molecular disintegration in the cell. With small doses we obtain a stimulation. Thus, with those small dosages we must be merely causing a slight disintegration and we may assume this disintegration involves only the water-soluble elements of the cell. As we increase the dosages we are disturbing the more stable elements of the cell in that we are causing a complete disintegration with higher dosages, or with dosages which are localized to a small area. We can determine the cellular change microscopically in the localized areas, and we have grounds to assume that a lesser degree of the same disintegration takes place in all of the cells of the body when this dosage is given in the form of a general body dose. It was found that Vitamin A alone added to a diet not

balanced in other constituents was not sufficient to protect the animal against the large dosage of X-ray, but that a well-balanced dietary had to be given. In other words, the animals which withstood best the higher dosages of X-rays were given a stock ration of dog biscuits, corn, vegetables, small amounts of meat *ad lib.*, to which was added the fat-soluble vitamin. These diets were prepared in such a way that the animal would eat an amount larger than ordinary. As noted by the protocol and weight curve, the fat-soluble vitamin may be given in a number of forms, the important factor being the amount. This was not so markedly shown in the studies of coal tar intoxication. A chemical ration to which cod liver oil was added protected the animal against coal tar intoxication almost as well as a balanced stock ration to which the same amount of cod liver oil was added (9). However, coal tar intoxication is the result of the changes taking place between the body and a localized area. Thus, this can be compared to the X-ray erythema, while it cannot be compared to giving a general body dosage of X-ray. When we commenced our work on the action of X-rays on cancer and normal tissue, we believed that the X-ray killed the growing cells entirely by acting directly on them. The work of Canti with the action of radium on cells *in vitro* gave one the same impression (10). In addition to this, his studies showed quite conclusively that the cells of the Jensen sarcoma were less resistant to radium than the fibroblasts of normal tissue. However, it has been shown clinically that there is always a latent period between the application of the rays and the death of cells in a body that has been subjected to radiation. This alone, with our careful study of the biological effect of X-rays, tends to make it seem more logical that the removal of the lipoid solvent from the tissue irradiated is the process by which the malignant tissue is destroyed. Studies have not revealed whether the lipoid solvent is removed more easily from malignant tissue than from normal tissue. However, our studies and others make it seem quite evident that there is a less amount of lipoid substance in cancer tissue than in normal tissue. There is a greater amount of the water-soluble stimulating substance in the cancer cell, and this would explain the apparent selectivity of radiant energy on malignant tissue. It has been demonstrated *in vitro* that an increase in cell stimulus to a high concentration will cause death of the cell, and immediate death must be due to the increase of this water-soluble stimulus. However, more complete studies must be made to compare further the circumstances as they take place in the culture tube and in the body. No doubt, there is more of the water-soluble element in the body available as it is destroyed in a local area, and it is apparently interchanged from one area to another, but at this time it seems that the taking up of the fat-soluble element of the cell is a more complex process and is not accomplished so readily, nor does it seem as possible to replace it in the cell.

EXPERIMENTAL OBSERVATIONS

In these studies the white rat, varying in weight from 60 to 130 grams at the beginning of the experiment, has been used. The main criterion used in a study of these effects has been the weight curves and the changes in length of life, as well as the effect on the litter-bearing properties of the animals.

Throughout all of these experiments the following X-ray dosage factors were employed:

The *intensity effect* of the X-ray beam in roentgen units was, respectively, 22.6 r per minute in air without back-scattering, and 31.0 r per minute on the skin, including back-scattering.

The *effective wave length measurement* of the filtered beam was 0.15 Ångstrom units

(the fraction of radiation passing through 1 mm. of copper).

Potential of 200 K.V. peak. (Spectrographic estimation of the minimum wave length 145 K.V.)

Filtration of ½ mm. Cu.

Focal skin distance of 80 cm.

Transformer, cross-arm type of rectification.

Water-cooled X-ray tube current employed was 25 milliamperes.

The *treatment fields* were limited to 25 cm. square, exposing six animals simultaneously in individual cardboard boxes, except when otherwise noted.

For the greater number of experiments we have used a chemical ration, varying the vitamin content of it by means of substituting Crisco for butter, or *vice versa,* or increasing or decreasing the quantity of these substances, and in some cases adding cod liver oil.

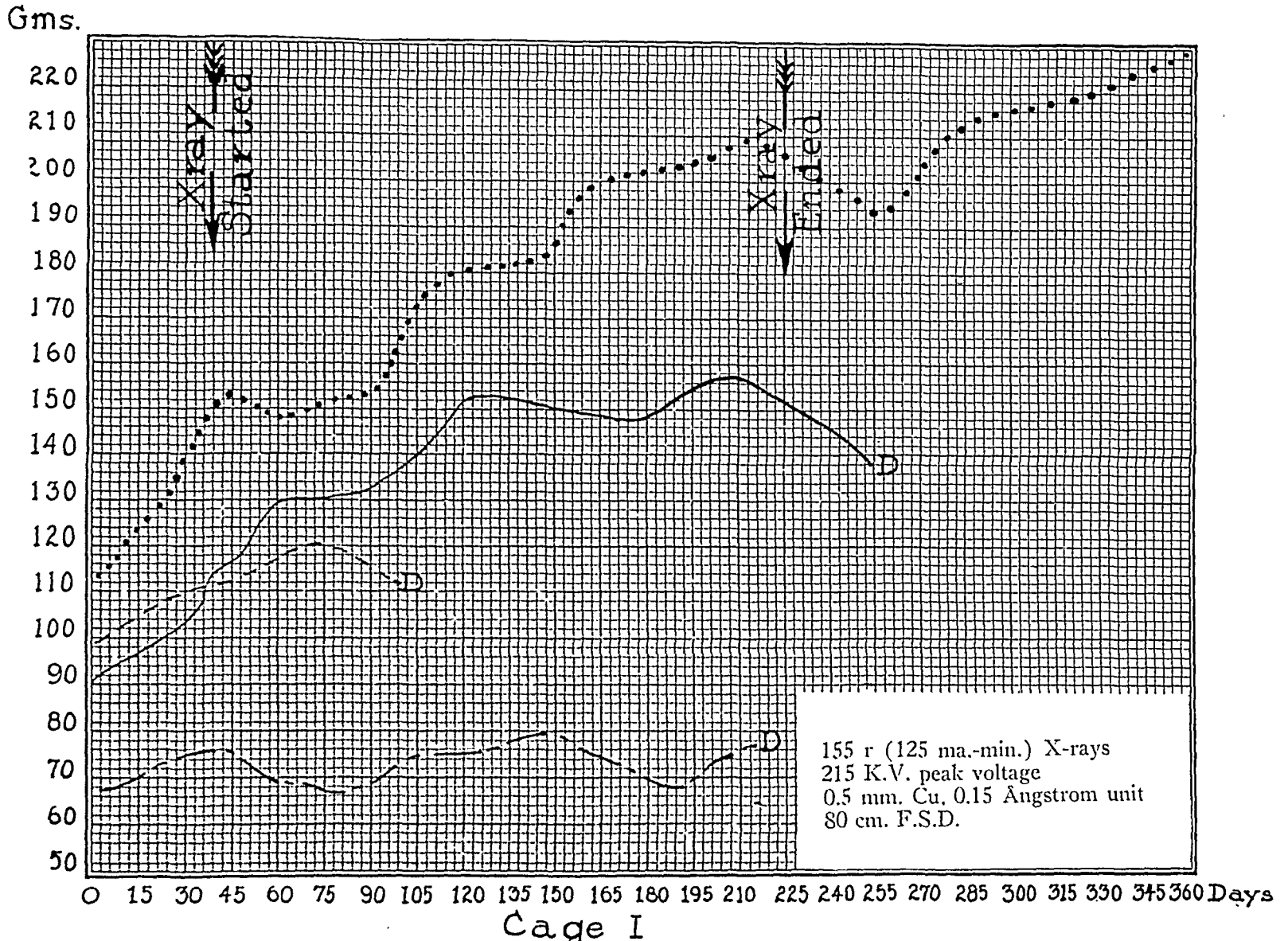
As stated above, it was found early in our experimental work that the increase in the Vitamin A fraction protected to a certain extent against the toxic effects of X-rays. In our early experiments we gave 12 r (10 ma.-min.) twice a week throughout the course of the experiment, and we increased this amount in the following experiments until at the present time we are giving 124 r (100 ma.-min.) and 155 r (125 ma.-min.) to separate series of rats twice a week over a period of time. It was found that with 12 r (10 ma.-min.) the Vitamin B of the diet was supplanted. With dosages above 62 r (50 ma.-min.) the Vitamin A fraction was supplanted. However, when 124 r (100 ma.-min.) was given twice a week the length of life of the animal was shortened on synthetic rations, especially when the Vitamin A fraction of the diet was not increased (11).

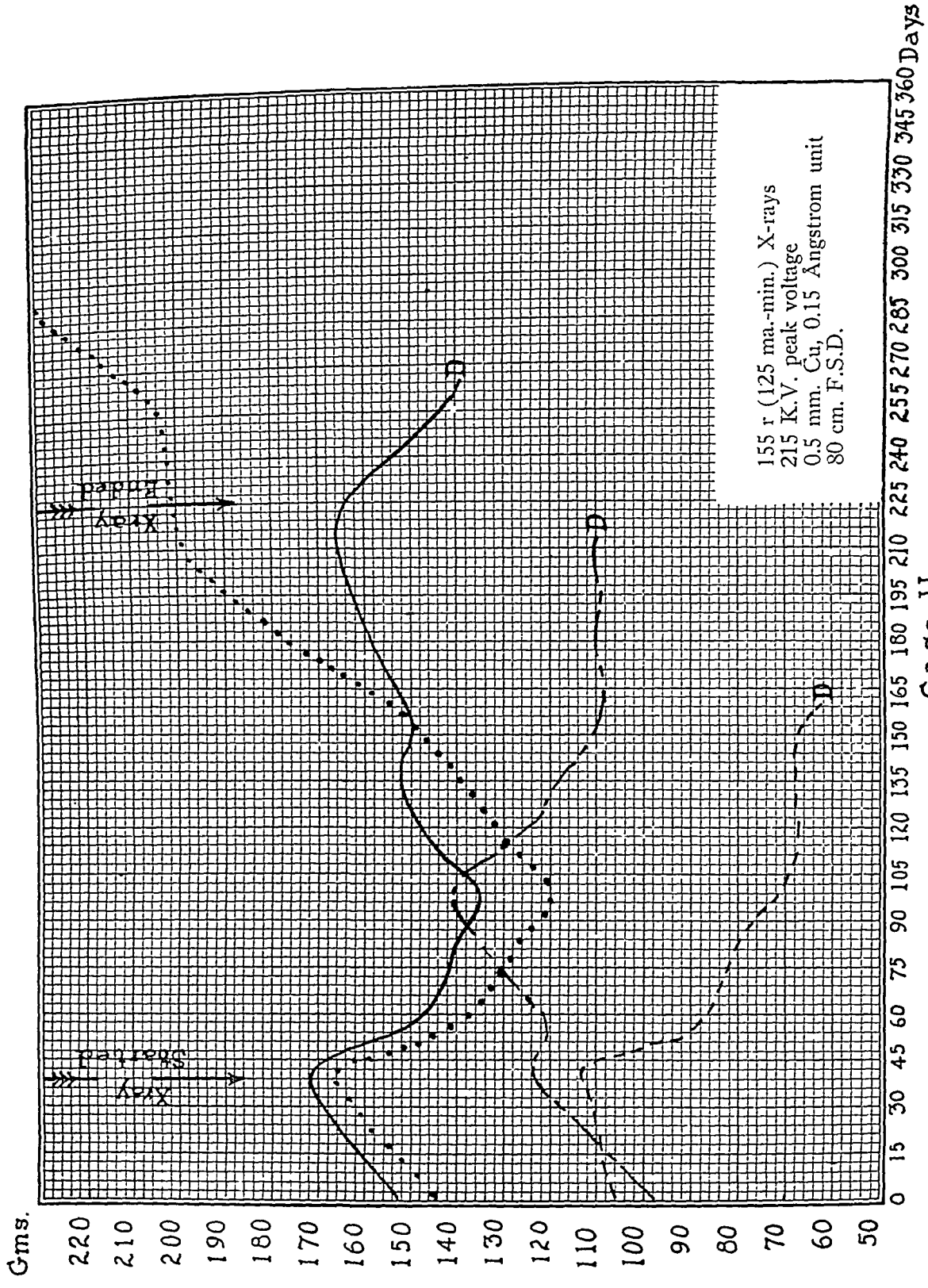
Thus, being aware of the fact that dog biscuits, lettuce and other vegetables, corn or wheat, given to animals *ad lib.,* produce a healthy rat, and in the female produce a healthy progeny in good sized litters, it became necessary to devise a method whereby the different concentrations of Vitamin A might be added to this dietary.

Because cod liver oil or its concentrates could not be mixed with the whole dog biscuit, the dog biscuits were ground and given to the animals *ad lib.* in dishes. As a control series, the ground dog biscuit was given *ad lib.* Lettuce and other greens were given twice a week, meat and corn on other days of the week, to the control and experimental series alike.

In the last experiment, in addition to this ration, 0.1 per cent of a cod liver oil concentrate, or 0.5 c.c. per 500 grams of dog biscuits, was given. In the third setup, the same amount of cod liver oil concentrate, and, in addition, 10 grams of Vegex per 500 grams of dog biscuits, was given. In the fourth setup, 3 per cent, or 15 c.c., of Mead's cod liver oil and 10 grams of Vegex, were given. In the fifth setup the Mead's cod liver oil in the same percentage, without the addition of Vegex, was added to the basic ration, while in the sixth setup, the dog biscuits were soaked in cream and given to the rats *ad lib.* The basic ration thus was the ration as given in the first experiment. The animals were placed on these rations for two weeks previous to being exposed to the X-rays, and the same diets were continued throughout the period of the experiment.

In former experiments, with the addition of 3 per cent Mead's cod liver oil to the basic ration, the rats attained an average weight of 200 grams at the end of six months, whereas at the beginning of the experiment they weighed from 50 to 80 grams. The amount of X-rays given to these animals was 124 r (100 ma.-min.) in one series, and 155 r (125 ma.-min.) in the other series. In the case where cream was given instead of cod liver oil, the increase in weight was not so marked, as the average


Gms.
220
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
X-ray Started
X-ray Ended
D
D
D
155 r (125 ma.-min.) X-rays
215 K.V. peak voltage
0.5 mm. Cu, 0.15 Ångstrom unit
80 cm. F.S.D.
0 15 30 45 60 75 90 105 120 135 150 165 180 195 210 225 240 255 270 285 300 315 330 345 360 Days
Cage I


Gms.
220
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
0 15 30 45 60 75 90 105 120 135 150 165 180 195 210 225 240 255 270 285 300 315 330 345 360 Days
Cage II
155 r (125 ma.-min.) X-rays
215 K.V. peak voltage
0.5 mm. Cu, 0.15 Ångstrom unit
80 cm. F.S.D.
X-ray Shielded
X-ray Exposed
D
D
D

weight at the end of the six-month period was 175 grams, the weight of the animals at the beginning being the same as in the former experiment.

In a series of experiments to determine the effect of changing the constituents in the basic portion, we were unable to find any substance which had any direct bearing on the toxic effect of the X-ray. The animals on the basic ration gained weight for a period of two months, and then remained stationary for a period of from fifteen to thirty days, or in some cases lost weight quite rapidly from the sixty-day period. Upon the addition of cod liver oil to the dietary, there was a gradual increase in weight from the beginning of the experiment, and this continued indefinitely.

In a previous article, Ernst outlined a method of measuring the X-rays in electrostatic e-units, which unit closely approximates the present international r-unit (12). Thus, throughout our experiments we have used the same quality of X-rays, varying only the quantity and determining the different reactions in the body. We contemplate further studies with the less penetrating or softer ray, given over the whole of the body. In the induction of the local X-ray erythema we used a softer ray and varied the dose so as to produce varying degrees of erythema or merely a transient inflammatory reaction. Then, too, we contemplate radiating foodstuffs to determine the effect of different quantities of the ray when administered in this way.

Jorstad had an opportunity recently to review the work of Dr. F. A. Hecker,[2] of Ottumwa, Iowa, who has been making a study of the tissue changes following X-ray burns. The tissue changes in his rats are similar to those Jorstad and Lane observed (13). He modified the procedure in some of his ries, in that he introduced a small of calcium chloride [illegible] time the X-ray was [illegible] in these animals sh[illegible] lignant change, an[illegible] metastases to lymp[illegible] of the body. Thi[illegible] chloride was injecte[illegible] out inducing the X-[illegible] preliminary rep[illegible] fore the Americ[illegible] mental Pathol[illegible] metastatic area[illegible] cium, and [illegible] present in [illegible] an area of [illegible] or the tar in[illegible]

Quite recen[illegible] perimented [illegible] The first [illegible] anced diet, [illegible] in additio[illegible] three time[illegible] painted w[illegible] days. [illegible] 21.5 pe[illegible] but in [illegible] Later [illegible] of m[illegible] cent [illegible] The [illegible] day[illegible]

It [illegible] sul[illegible] in [illegible] fo[illegible] re[illegible] V[illegible] n[illegible] z[illegible]

2Hecker, F. A. Personal co[illegible]ication sented before the Radiological Society of Fifteenth Annual Meeting, at Toronto, Dec,

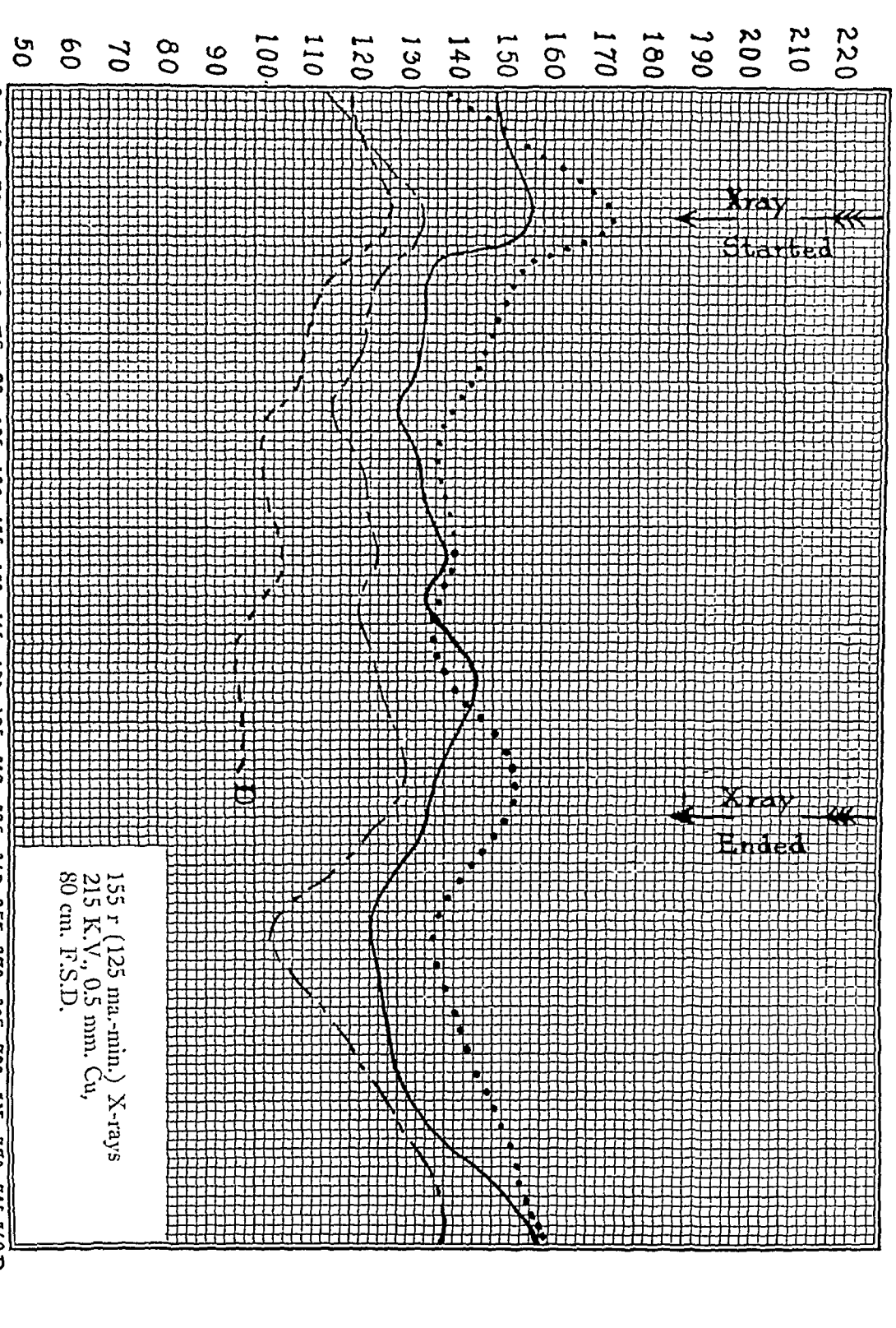
animal on a high Vitamin A dietary, but other fatty changes occur in this animal. When we used a lipoid solvent which did not have the marked viscosity of coal tar, or if we mixed coal tar with a less viscid lipoid solvent, such as Mazola oil, we noted that within 60 days or earlier, these rats which had been doing very well up to that time developed a marked fatty infiltration of the liver. The liver, of course, is the largest storehouse of fat in the body—a fat which is quite easily available for use by the body.

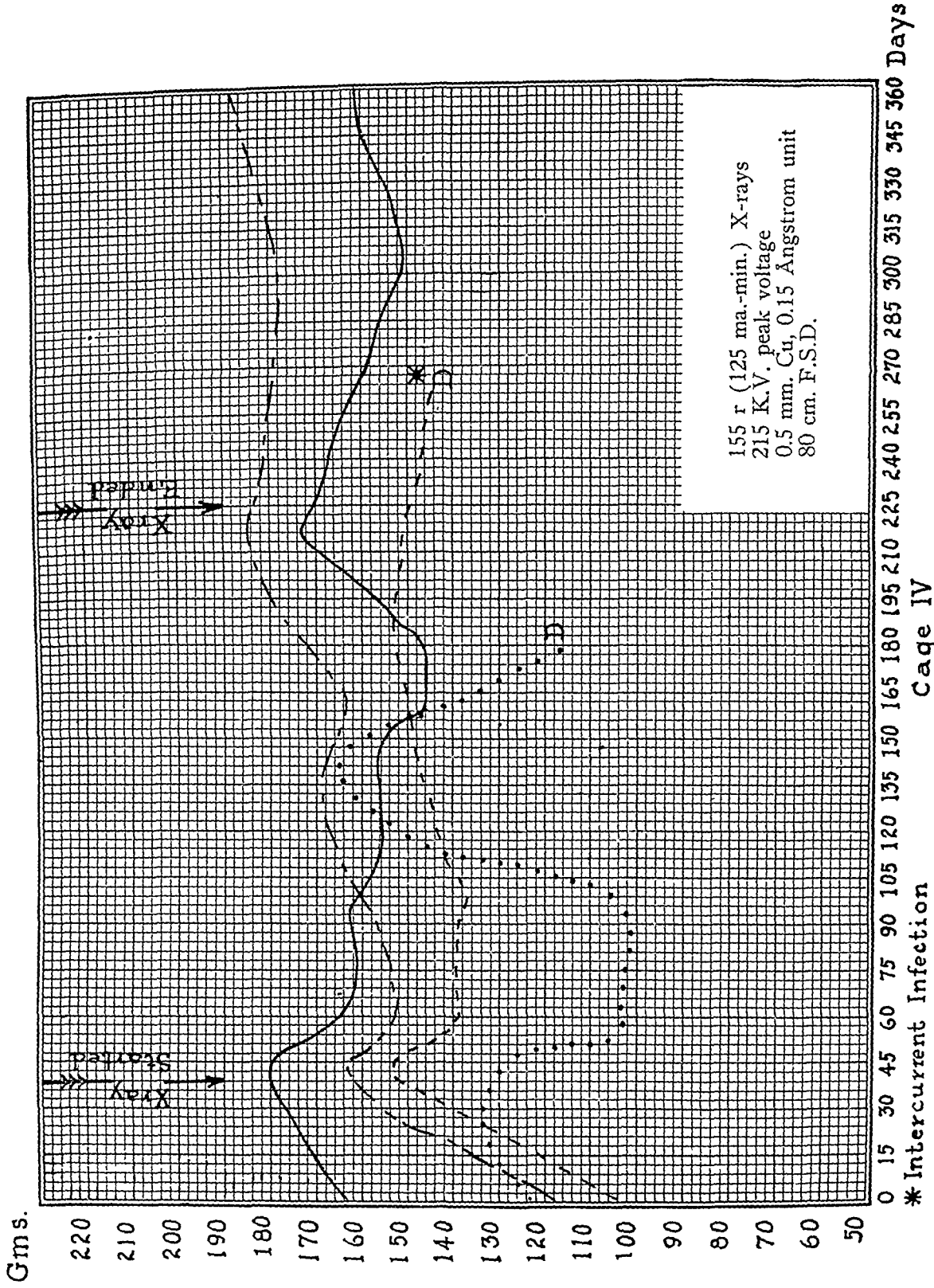
It is not unreasonable to assume that one and the same group of substances contained in body fat is responsible for this entire mechanism. That calcium chloride may disturb this same mechanism, or that liver may disturb the same mechanism, or that a lipoid solvent may be responsible for such a disturbance, points to this assumption. It does not mean that we are dealing with a number of substances, because all of them are closely allied with the metabolism as affected by Vitamin A, especially when one considers Vitamin D as a part of Vitamin A, or that the marked changes induced in the infant or growing child by Vitamin D must have a counterpart in the older individual, the change in that case being produced by Vitamin A.

DISCUSSION

In a study of the weights listed as of different intervals of time during the course of several experiments, a number of findings are of interest. In Experiment No. 60, the only rats of 75 to 100 grams weight at the beginning of the experiment that survived the six-month period were those fed on a stock ration to which had been added 3 per cent by weight of cod liver oil. These rats gained weight throughout the period of observation.

In Experiment No. 61, the animals fed Ration V, in which wheat was substituted for meat, and Ration IV, in which cream was substituted for meat, showed the most marked gain in weight and survived for the longer period of time. These rats received 155 r (125 ma.-min.) of X-rays twice a week instead of 124 r (100 ma.-min.) of X-rays, as given in Experiment No. 60. We have published data in previous papers (*loc. cit.*) showing the effect of 124 r (100 ma.-min.) of X-rays on the weight curve of the rat on different dietaries. It is interesting to note that the increase in weight during the first or second month is not so marked in Experiment No. 61 as in Experiment No. 60. For comparison, note also Rations I and V, in Experiment No. 60, and Rations IV and V, in Experiment No. 61. The curves plotted from weekly readings of the weights obtained with these rations show the definite undulations, which become more marked as the X-ray administrations increase in number. These undulations follow the first transient decline in weight noted directly after the first X-ray dose. The extent of the declinations becomes less accentuated as the experiment progresses, and is less marked in the animals given the rations which withstood the X-rays best as determined by gain in weight and length of life. It is possible that this may indicate the development of a resistance to X-ray as the result of repeated exposures. Some investigators may view this as evidence that the X-ray plays the part of an antigen in the body, setting free cytolytic ferments, which, in turn, cause the liberation of immune bodies in the nature of anti-ferments. The clinical results obtained with the X-ray in the treatment of erysipelas are difficult to explain on any other basis than that of antibody or tissue enzyme liberation. The setting up of tissue enzymes is a more plausible assumption than that of a direct bacteriolysis. It has been quite definitely shown by a number of workers in the past few years that fat-splitting ferments are important factors in the immune reactions in the body.


Gms.
220
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
X-ray Started
X-ray Ended
155 r (125 ma.-min.) X-rays
215 K.V., 0.5 mm. Cu,
80 cm. F.S.D.
Cage III
0 15 30 45 60 75 90 105 120 135 150 165 180 195 210 225 240 255 270 285 300 315 330 345 360 Days


Gms.
220
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
X-ray Scattered
X-ray Carried
155 r (125 ma.-min.) X-rays
215 K.V. peak voltage
0.5 mm. Cu, 0.15 Ångstrom unit
80 cm. F.S.D.
0 15 30 45 60 75 90 105 120 135 150 165 180 195 210 225 240 255 270 285 300 315 330 345 360 Days
* Intercurrent Infection
Cage IV

EXPERIMENT NO. 60

124 r (100 ma.-min.) X-rays twice a week for duration of experiment

Ration	Weights beginning	One month later	Two months later	Six months later
I	80 gm.	120 gm.	120 gm.	All dead at 90 days
	102 gm.	120 gm.	110 gm.	
	96 gm.	120 gm.	112 gm.	
	103 gm.	130 gm.	130 gm.	
II	101 gm.	114 gm.	94 gm.	All dead at 85 days
	106 gm.	119 gm.	130 gm.	
	81 gm.	101 gm.	98 gm.	
	72 gm.	95 gm.	80 gm.	
III	91 gm.	119 gm.	120 gm.	All dead at 70 days
	80 gm.	99 gm.	106 gm.	
	96 gm.	105 gm.	92 gm.	
	104 gm.	134 gm.	130 gm.	
IV	89 gm.	100 gm.	104 gm.	All dead at 90 days
	90 gm.	120 gm.	108 gm.	
	100 gm.	125 gm.	120 gm.	
	82 gm.	103 gm.	112 gm.	
V	78 gm.	103 gm.	150 gm.	165 gm.
	79 gm.	110 gm.	170 gm.	200 gm.
	80 gm.	104 gm.	150 gm.	175 gm.
	86 gm.	136 gm.	175 gm.	210 gm.

EXPERIMENT NO. 61

155 r (125 ma.-min.) X-rays twice a week for duration of experiment

Ration	Weights beginning	One month later	Two months later	Six months later
I	94 gm.	102 gm.	112 gm.	All dead at from 100 to 140 days
	78 gm.	88 gm.	100 gm.	
	102 gm.	110 gm.	116 gm.	
	108 gm.	117 gm.	124 gm.	
II	106 gm.	114 gm.	118 gm.	All dead at from 70 to 90 days
	82 gm.	89 gm.	92 gm.	
	78 gm.	85 gm.	94 gm.	
	95 gm.	102 gm.	105 gm.	
III	92 gm.	104 gm.	116 gm.	All dead at 140 days
	81 gm.	94 gm.	108 gm.	
	100 gm.	109 gm.	132 gm.	
	79 gm.	86 gm.	100 gm.	
IV	116 gm.	124 gm.	133 gm.	All dead at 145 days
	122 gm.	131 gm.	141 gm.	
	94 gm.	102 gm.	112 gm.	
	88 gm.	97 gm.	107 gm.	
V	106 gm.	117 gm.	136 gm.	All dead at from 110 to 140 days
	118 gm.	128 gm.	135 gm.	
	96 gm.	118 gm.	127 gm.	
	84 gm.	117 gm.	127 gm.	

Thus, with the smaller doses of X-rays which induce a transitory change in tissue, it may be possible that the change is mainly the setting free of ferments. The actual measurements we obtained in former experiments as to the liberation of Vitamin B or A, depending on the quantity of X-ray given, do not refute but rather tend to substantiate this idea. The larger doses of X-rays causing a definite destruction of protoplasm do more than cause a liberation of ferments, however. The tissue destruction is permanent.

The gross observations of the animals on Ration II in Experiment No. 61 were more striking than the weight curves, as these animals did very badly, while the animals on Ration V in the same experiment did not show the loss of weight or lack in gain, diarrhea, and inactivity such as were present in the former setup. This was not due to a smaller consumption of wheat on account

EXPERIMENT NO. 62

124 r (100 ma.-min.) X-rays twice a week for duration of experiment

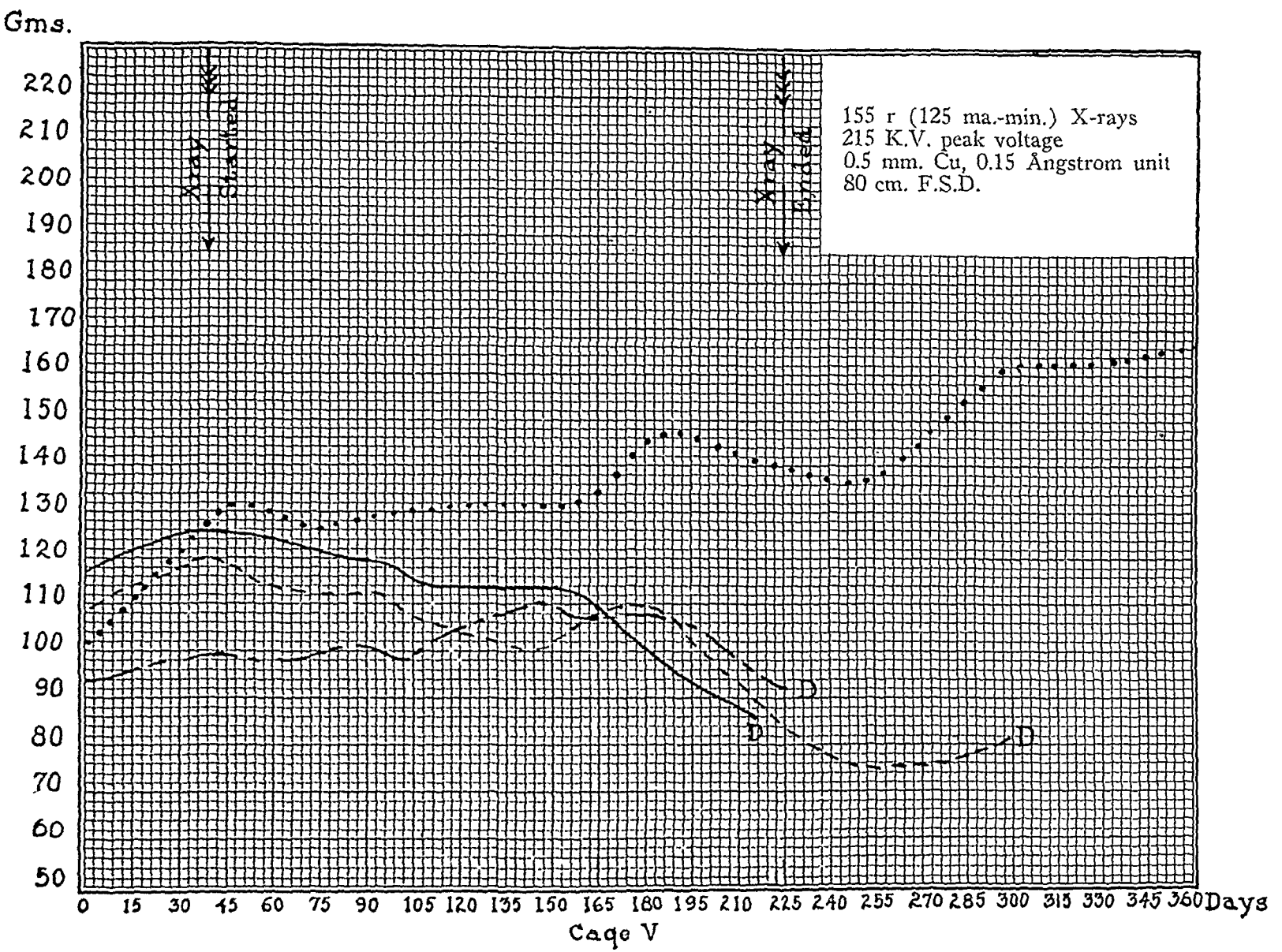
Ration	Weights at beginning	One month later	Two months later	Six months later
I	130 gm.	135 gm.	134 gm.	142 gm.
	143 gm.	143 gm.	142 gm.	155 gm.
	92 gm.	101 gm.	126 gm.	140 gm.
	61 gm.	67 gm.	85 gm.	114 gm.
II	135 gm.	138 gm.	140 gm.	D
	113 gm.	133 gm.	132 gm.	D
	68 gm.	80 gm.	87 gm.	D
	89 gm.	89 gm.	90 gm.	D
III	134 gm.	145 gm.	154 gm.	160 gm.
	116 gm.	130 gm.	140 gm.	152 gm.
	60 gm.	77 gm.	95 gm.	110 gm.
	58 gm.	67 gm.	93 gm.	115 gm.
IV	155 gm.	166 gm.	180 gm.	165 gm.
	143 gm.	136 gm.	139 gm.	138 gm.
	56 gm.	86 gm.	122 gm.	123 gm.
	60 gm.	82 gm.	106 gm.	96 gm.
V	148 gm.	170 gm.	173 gm.	173 gm.
	177 gm.	190 gm.	200 gm.	200 gm.
	63 gm.	100 gm.	123 gm.	150 gm.
	68 gm.	102 gm.	128 gm.	190 gm.
VI	67 gm.	69 gm.	69 gm.	79 gm.
	148 gm.	160 gm.	175 gm.	172 gm.
	78 gm.	127 gm.	156 gm.	200 gm.
	72 gm.	120 gm.	148 gm.	186 gm.

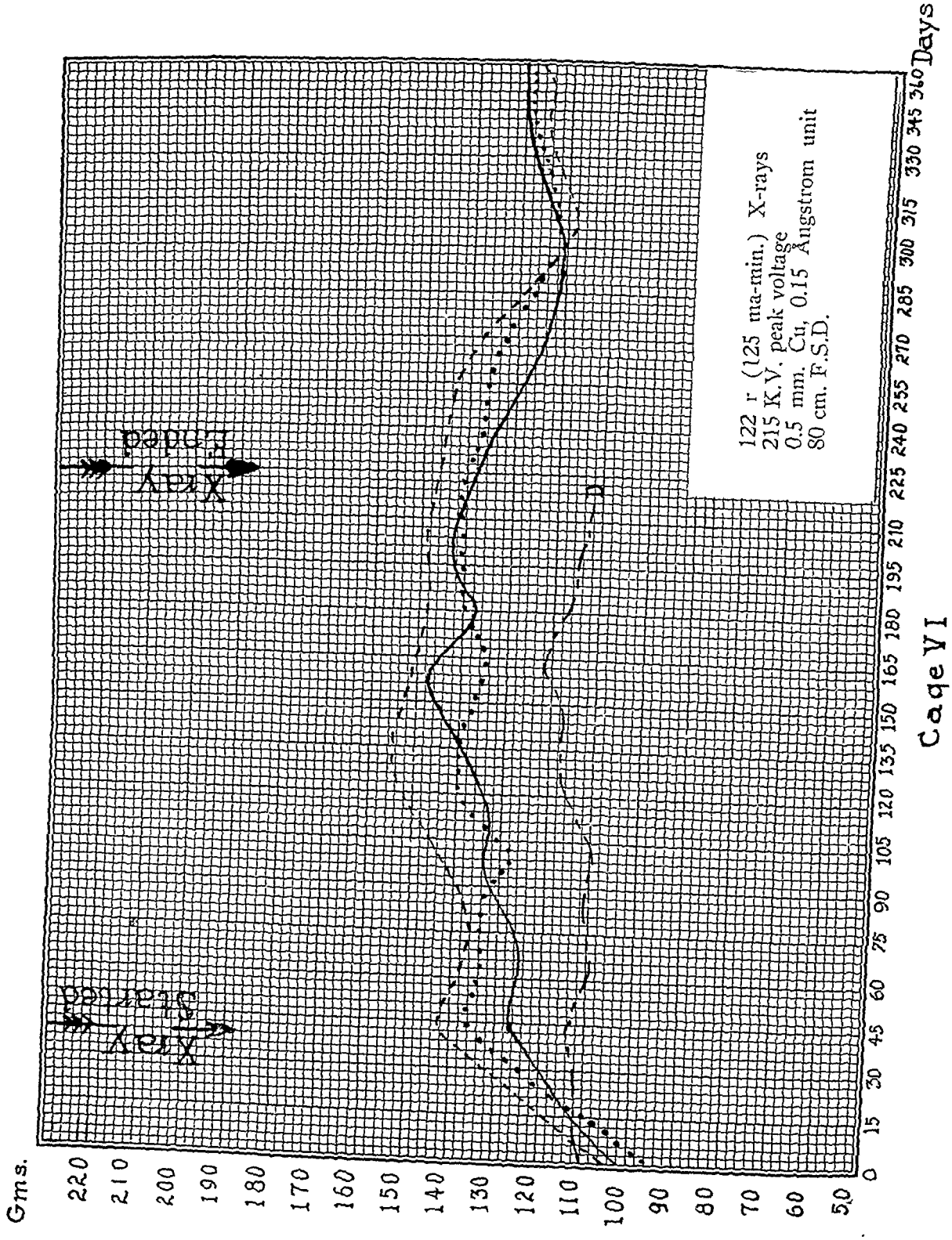
of the availability of carrots and lettuce, as the quantity consumed in each experiment was practically the same. Then, too, this contrast between animals fed dog biscuits and cracked corn, and animals fed dog biscuits, cracked corn, and vegetables, has not been noted. We have not investigated further the apparent untoward results obtained by using wheat as a substantial part of the ration. We have repeated this setup with the same results.

In Experiment No. 62, some of the rations in Experiment No. 61 have been repeated, and 124 r (100 ma.-min.) have been given instead of 155 r (125 ma.-min.). Weights of from 60 to 90 gram rats and of from 120 to 150 gram have been tabulated to note if animals of different age levels respond differently. Aside from the observations noted above, the findings of note here have been the protective action of Ration V, and the similarity of weight curves of the younger and older animals.

As a result of these and former studies, it seemed logical to assume that an increase in the fat-soluble vitamins in a well balanced ration would be most protective against larger dosages of X-rays. It had not been determined, however, whether an increase in the Vitamin B fraction would produce a difference in protectivity in the presence of this increase in Vitamin A. Thus, in Experiment No. 64, the stock ration was used as a basic control ration, and Vitamin B and Vitamin A added as noted in the protocol.

With one exception the results obtained with Ration I in Experiment No. 64 compare favorably with Ration I in Experiment No. 60. This rat received the same dietary and the same amount of X-ray as the remainder of the rats in the cage. This same phenomenon occurred with Ration II in Experiment No. 64, which may be considered a coincidence, as both of these setups have been repeated. It has been noted in previous experiments, not alone in this series, that occasionally one animal in a group will respond differently from the others. Such observations have been recorded clinically also and have been interpreted on the basis of a difference in individual reactivity. This is especially true in radiation therapy.


Gms.
220
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
X-ray Stopped
X-ray Started
155 r (125 ma.-min.) X-rays
215 K.V. peak voltage
0.5 mm. Cu, 0.15 Angstrom unit
80 cm. F.S.D.
D
D
D
0 15 30 45 60 75 90 105 120 135 150 165 180 195 210 225 240 255 270 285 300 315 330 345 360 Days
Cage V


Gms.
220
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
0 15 30 45 60 75 90 105 120 135 150 165 180 195 210 225 240 255 270 285 300 315 330 345 360 Days
X-ray Started
X-ray Ended
122 r (125 ma-min.) X-rays
215 K.V. peak voltage
0.5 mm. Cu, 0.15 Angstrom unit
80 cm. F.S.D.
Cage VI

EXPERIMENT NO. 64

155 r (125 ma.-min.) X-rays twice a week for period of six months

Ration	Weight at beginning	One month later	Two months later	Six months later	One year later
I	72 gm.	73 gm.	77 gm.	Dead	
	105 gm.	135 gm.	150 gm.	148 gm.	Dead
	160 gm.	170 gm.	200 gm.	188 gm.	230 gm.
	130 gm.	135 gm.	145 gm.	Dead	
II	175 gm.	135 gm.	150 gm.	170 gm.	Dead
	170 gm.	120 gm.	150 gm.	203 gm.	260 gm.
	125 gm.	140 gm.	110 gm.	110 gm.	Dead
	110 gm.	70 gm.	65 gm.	Dead	
III	130 gm.	120 gm.	100 gm.	105 gm.	Dead
	160 gm.	130 gm.	130 gm.	140 gm.	160 gm.
	140 gm.	120 gm.	120 gm.	130 gm.	175 gm.
	180 gm.	130 gm.	140 gm.	140 gm.	180 gm.
IV	180 gm	160 gm.	145 gm.	160 gm.	185 gm.
	175 gm	100 gm.	95 gm.	Dead	
	170 gm	160 gm.	160 gm.	180 gm.	190 gm.
	160 gm.	135 gm.	145 gm.	150 gm.	180 gm.
V	100 gm	100 gm.	110 gm.	108 gm.	Dead
	130 gm.	125 gm.	110 gm.	90 gm.	Dead
	120 gm.	110 gm.	105 gm.	80 gm.	Dead
	125 gm.	130 gm.	130 gm.	150 gm.	165 gm.
VI	112 gm.	110 gm.	125 gm.	130 gm.	Dead
	140 gm.	140 gm.	155 gm.	140 gm.	125 gm.
	140 gm.	130 gm.	150 gm.	135 gm.	130 gm.
	130 gm.	130 gm.	150 gm.	125 gm.	125 gm.

There is a difference in the effect of radiation therapy on tumors and there is a difference in effect, or we may say reaction, in different individuals given the same amount of radiation. In comparing the weight curves on Rations III, IV, and VI in Experiment No. 64, it is to be noted that the weight changes are different after X-ray administration is stopped (Charts I to VI). There is a gradual increase in weight after the last decline of the curve following the last X-ray exposure. It is interesting to note that this same finding is true of the remaining rat in Cage 1 and Cage 2 also. The steadily mounting but undulating weight curve is present in each setup. Of the whole series, Ration III is the most protective. In a study of this curve the increase in weight after the last X-ray exposure is practically the same as the increase in weight noted before the X-ray was started. This is to be compared with the weights on Ration VI. Ration IV is practically equally as protective as Ration III. However, when one compares the initial gain in weight before the X-ray was started, the undulations of the weight curve during the period of X-ray treatment, the period of decline in weight after the X-ray was ended, taking into consideration the loss of one animal at this time, and the less marked gain in weight following this decline, Ration III seems the most protective, even though there was a more marked loss of weight in this series during the period over which X-ray was given. It is interesting that both of these rations contained Vegex in addition to the cod liver oil, and cod liver oil concentrate,[3] respectively. The gross clinical findings and autopsy on these animals show nothing of interest. It is worthy of remark that in this experiment as well as in others rats on a ration to which cream has been added survive and show no marked untoward signs and symptoms under X-ray therapy; they look healthy and are active during the course of the experiment, but they never attain the

[3]This concentrate was furnished by the Vitamin Food Company, of Westfield, Massachusetts.

weight that is noted in other animals on rich Vitamin A rations.

CONCLUSIONS

1. The white rat withstands relatively large amounts of X-radiation given at biweekly intervals over a period of time if cod liver oil is added to a well balanced stock ration.

2. Even though a well balanced ration rich in Vitamin A is protective, the rats do not gain weight as rapidly during the period of X-ray exposures as they do previous to and following this period.

3. Occasional exceptions to this rule are noted.

We wish to take this opportunity to state our appreciation of the special efforts made by Miss G. Boehm in carrying out the laborious routine necessary in numerous dosages of X-ray. We also wish to thank the Barnard Free Skin and Cancer Hospital and the Community Fund of St. Louis, through whose financial assistance it was possible to carry out this work.

PROTOCOL

Experiment No. 60.—Ration I, stock ration of dog biscuits, lettuce, cracked corn, meat, and water; *Ration II,* dog biscuits and water: *Ration III,* dog biscuits, meat, and water; *Ration IV,* dog biscuits, meat, lettuce, and water; *Ration V,* dog biscuits with 3 per cent by weight of cod liver oil, meat, lettuce, and water.

Experiment No. 61.—Ration I, dog biscuits, cracked corn, and water; *Ration II,* dog biscuits, wheat, and water; *Ration III,* dog biscuits, carrots, lettuce, and water; *Ration IV,* dog biscuits (soaked in cream), lettuce, carrots, and water; *Ration V,* dog biscuits, carrots, lettuce, wheat, and water.

Experiment No. 62.—Ration I, dog biscuits, corn, and water; *Ration II,* dog biscuits, wheat, and water: *Ration III,* dog biscuits, lettuce, carrots, and water; *Ration IV,* dog biscuits, lettuce, carrots, spinach, and water; *Ration V,* dog biscuits (soaked in cream), carrots, spinach, lettuce, and water; *Ration VI,* dog biscuits, carrots, lettuce, spinach, wheat, and water.

Experiment No. 64.—Ration I, stock ration, same as Experiments No. 60 and 61; *Ration II,* 0.1 per cent cod liver oil concentrate, or 0.5 c.c. per 500 grams of material added to Ration I; *Ration III,* 2 per cent of Vegex, or 10 grams, added to Ration II; *Ration IV,* 3 per cent of Mead's cod liver oil, or 15 c.c. per 500 grams of material, and 2 per cent of Vegex, or 10 grams, added to Ration I; *Ration V,* 3 per cent of Mead's cod liver oil, or 15 c.c. per 500 grams of material added to Ration I; *Ration VI,* one-quarter pint of cream per 100 grams of material added to Ration I.

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FURTHER STUDIES ON THE SKIN ERYTHEMA WITH COMBINATIONS OF TWO TYPES OF RADIATION[1]

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IT is axiomatic in radiation therapy that the amount of radiation which can be delivered to a given point through one skin portal is strictly limited by the amount the skin will tolerate. With a realization of the need in many cases for larger doses of radiation, have come various efforts to increase this tolerance limit. These have taken two forms: (1) An attempt to find something which could be applied to the skin to "toughen" it, or decrease its sensitivity, and (2) an attempt to vary the dosage technic in some manner so that the skin would permit the use of more radiation. One method of this kind which seemed to give some satisfactory results was to use combinations of different types of radiation in the treatment of the case, rather than to rely on a single type. Clinically it seemed that such combinations were at times more effective, but it is difficult to draw definite conclusions with regard to such a question from clinical evidence alone. In order to obtain an evaluation of the advantage of such a method of treatment two points must be settled: (*a*) Does the skin actually tolerate more radiation when combinations of different types are used? (*b*) Does the tumor also tolerate more of the combined radiation, or is there a differential action, so that the combination acts less strongly on normal skin, but at least as strongly on tumor tissues, as any one type alone? This second question is just as important as the first, but is often ignored.

In the present paper it is proposed to answer the first question for a number of combinations of radiations, ranging from hard beta rays through soft and hard X-rays, to gamma rays. Some of this material has already been published (1, 2), but it seems advisable to collect it all together here. The second question will not be touched upon in this paper, but we wish to emphasize the fact that until it is answered the method of treatment with combinations of different radiations has not been proved more efficient than the use of a single type of rays.

The method of measuring the amount of radiation used is obviously very important. The use of any physical scheme might introduce a grave source of error, for it has not been shown that the skin erythema dose is independent of the quality when the quantity of radiation is measured by any of the various physical or biological units which have been suggested. We have avoided any such difficulty by the simple device of measuring the quantity for each type of radiation by the very effect we are studying. That is, in each case, keeping the output of the source of radiation constant, we have determined the time necessary to produce the threshold erythema.[2] Then half the dose will be given in half the time, and so on. The question of variation in effect with duration of the irradiation does not enter for such differences of time as exist between a half and a full dose of any type of radiation used in these experiments. The various sources were so arranged that it took about the same length of time for each to produce an erythema. This method of determining the quantities of radiation used makes unnecessary the use of any measur-

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[2]The threshold erythema is the dose which, in 80 per cent of all cases treated, produces a faint reddening or bronzing of the skin two or three weeks after irradiation, and in the other 20 per cent no visible effect. By observing a large number of cases it is possible to determine this dose with much greater accuracy than one producing a definite color reaction. Fifty to sixty tests were made with each type of radiation in determining its threshold erythema dose.

ing instrument other than a timepiece, except for the purpose of checking the constancy of the output of radiation.

Five types of radiation were used, two at a time, in various combinations. They will be described in detail, and afterward referred to by their numbers.

I. *Gamma rays.*—(*a*) In the first series of experiments involving gamma rays the source was a radon tube having a filter of 0.5 mm. silver, 1.0 mm. brass, and 2.4 mm. rubber—the standard gamma-ray filter in use at the Memorial Hospital at that time. This was used at distances of 5 and 10 mm. from the skin. The threshold erythema was produced by 64 mc.-hr. at 5 mm.; 290[3] mc.-hr. at 10 mm. (*b*) For later series of gamma-ray experiments, the source was two tubes of radium sulfate, 20 mm. long and 4 mm. in diameter, placed side by side in a holder of balsa wood and hard rubber, the filter being 0.5 mm. platinum and 9 mm. of rubber and wood. In this case the radium-to-skin distance measured from the center of the tube was 10 millimeters. Two hundred ninety-five[3] mg.-hr. were required to produce the threshold erythema under these conditions.

II. *Radium radiation predominantly beta.*—The source was a radon tube filtered by 0.16 mm. brass and 1.2 mm. rubber. This filter removed the softest rays and left a mixture consisting of about 67 per cent beta rays and 33 per cent gamma rays.[4] This was used at 10 and 40 mm. from the skin, the threshold erythema being produced by 8 mc.-hr. and 115 mc.-hr., respectively.

III. *Hard X-rays.*—The source was a constant potential machine equipped with kenetrons and condensers, and the output was very constant. The specifications of the radiation were 165 K.V. (measured spectrographically), 3 ma., 0.4 mm. copper and 1 mm. aluminum filter, 50 cm. target-skin distance, 3 × 3 cm. area on skin, 295 ma.-min. required to produce threshold erythema.

IV. *Soft X-rays.*—The source was a mechanical rectifier outfit providing radiation at 30 K.V. (approximately), 4 ma., 1 mm., aluminum filter, 15 cm. target-skin distance, 3 × 3 cm. area on skin, 150 ma.-min. required to produce threshold erythema. The output of this machine was not so constant as that of the kenetron apparatus, but it was carefully controlled by ionization measurements and due allowance made for small variations.

V. *Ultra-violet rays.*—The source was a quartz mercury arc operated at 80 volts and 3.6 amperes. With a 50 inch lamp-to-skin distance a threshold erythema was produced for a 5 × 5 cm. area in 16 minutes. This was a well-seasoned lamp. It was necessary to run it for about half an hour each time before it attained a steady output, but after that it was quite constant.

The combinations investigated were I and II, I and III, I and IV, and IV and V, equal parts of the two radiations under consideration always being used.

The method of procedure in every series of experiments was the same. First the threshold erythema dose for each individual radiation was determined. The method of doing this has been published in detail (2) and will not be repeated here. For the combination, using one of the two types, from 40 to 70 per cent of an erythema dose was

3We wish to call attention to the close agreement in these two threshold erythema doses obtained by two observers independently. It is often stated that any use of skin erythema as a quantitative standard is of little value because it is impossible to observe the reaction with sufficient accuracy. This is doubtless true when a definite degree of reddening is considered. The threshold erythema which we have used is not open to this objection. Our argument on this point is well supported by the evidence here shown. For the first series of these doses, determined some years ago, the tests were made by one of us (E. H. Q.). For the second, obtained during the past year, the observations were made by the other (G. T. P.). The applicators were not identical, but the radium-to-skin distance was the same and the radiating area and filter were practically equivalent. Hence the threshold dose should be the same for both. And the ones experimentally determined as just stated, agree within less than 2 per cent.

4The reason for using a small filter in addition to the bare glass tube was to avoid errors due to small differences in the thickness of the glass walls of the radon tubes. Such variations would produce large variations in the amounts of very soft radiations transmitted. Therefore it seemed better to use a filter which would eliminate this very soft radiation in any case.

given to the right leg, just above the knee. The corresponding dose of the second type was administered to the same area immediately afterward. Then a different dose of the second type was used on the left leg, followed immediately by the corresponding dose of the first type Thus for every combination two complete series of tests were made, in either one of which the order of the irradiations was the reverse of the other. It may be said at once that in no case did it make any difference which radiation was used first. At least ten patients were tested with each quantity of combined radiation, and the percentage of positive results for this amount observed. Figure 1 shows the method of plotting these percentages and the corresponding doses. The data of this figure are for the combination I and IV. From the curve the quantity which gives 80

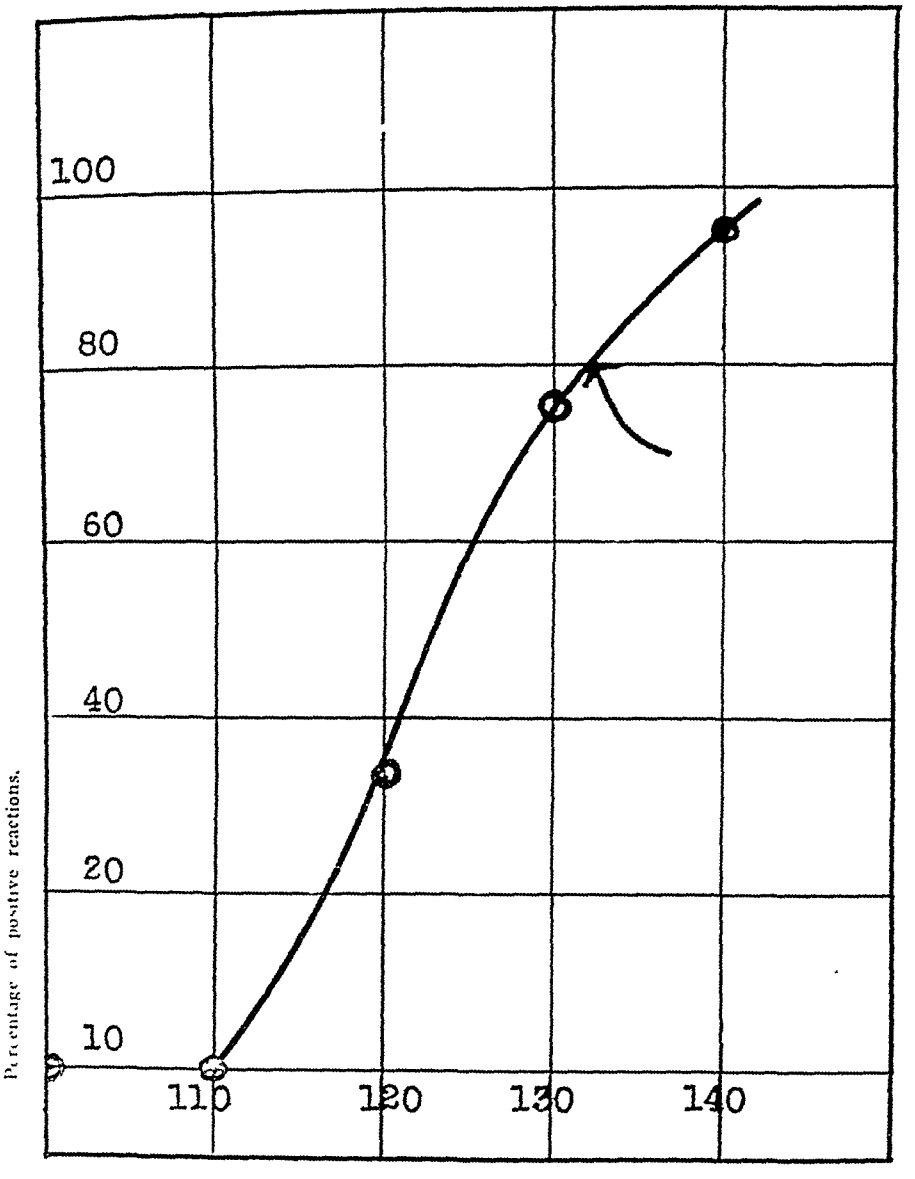


Fig. 1. Curve for determining threshold erythema dose for a combination of equal parts of gamma rays and soft X-rays.

TABLE I

AMOUNTS OF RADIATION NECESSARY TO PRODUCE THRESHOLD ERYTHEMA: VARIOUS TYPES OF RAYS USED SINGLY AND IN COMBINATIONS OF EQUAL PARTS OF TWO

For Any Single Type, 100 Per Cent of the Dose Produces the Erythema	
Combinations	Percentage of Combined Radiation Required
Beta and Gamma Rays (Both Sources 10 mm. from Skin)	133
Beta and Gamma Rays (Gamma Source 5 mm., Beta 40 mm. from Skin)	135
Gamma Rays and Hard X-rays	133
Gamma Rays and Soft X-rays	132
Soft X-rays and Ultra-violet Rays	More than 150

per cent of positive reactions can be read immediately—in this case, 132. That is, for this particular combination it requires 32 per cent more radiation to produce the threshold erythema than for either component alone. Table I shows the required doses for the various combinations tested.

From these data it is evident that, for all the combinations tested, it takes one-third more of the combined radiation to produce the threshold erythema than for any single type. This is rather surprising. There is no reason for expecting that combinations of such widely different types of radiation should agree in such a manner. In fact, such perfect agreement is probably fortuitous, although there is no doubt regarding the actual increase. A study of the errors which might occur in such experiments has already been published (2) and need not be repeated. The conclusion is that the error in determining any one threshold erythema dose is not more than 6 per cent. Making due allowance for such possible errors, it is still apparent from the table that for the four combinations of radium and X-radiation studied there is an actual increase in the quantity of radiation necessary to produce the observed reaction, and that this increase is practically the same for all combinations, namely, about one-third of the dose.

The erythema and pigmentation are visible evidences of phenomena occurring in fairly superficial layers of tissue. David and Gabriel (3) and Pohle (4) studied capillary changes after irradiation by means of a skin microscope. Phenomena thus visible probably occur within the first 2 millimeters of tissue. The pigment cells, to which the visible tanning is to be attributed, lie in the dermis or epidermis. They are not more than 2 millimeters below the surface in the skin of the thigh, and probably less. It is likely that changes in underlying tissues have some effect on capillary or pigment cell reactions, but it is hardly probable that anything deeper than 1 centimeter would be of any importance in this connection. We have, therefore, studied the distributions of these radiations in the first centimeter of tissue to see if we could find therein an explanation of the increased tolerance of the skin to the combined treatments.

In combination No. 1, with beta and gamma ray sources at the same distance from the skin, it is evident that the distribution of the two types of rays would be very different, and that of the combination quite different from either. If the distance of any applicator from the skin is changed, it is obvious that the distribution of the radiation in the tissue will be changed also. Increasing the distance, of course, will have the effect of increasing the percentage depth dose, while decreasing the distance will have the reverse effect. Therefore, if the gamma ray applicator is moved closer to the skin,

TABLE II

DISTRIBUTION OF VARIOUS TYPES OF RADIATION IN FIRST CENTIMETER OF TISSUE

Depth in Tissue mm.	Percentage of Radiation Delivered at Depth					
	I Gamma Rays at 10 mm.	II Gamma Rays at 5 mm.	III Beta Rays at 10 mm.	IV Beta Rays at 40 mm.	V X-rays Hard	VI X-rays Soft
0	100	100	100	100	100	100
1	82	75	62	70	100	97
2	69	57	39	51	99	90
3	57	46	27	39	98	85
5	42	30	14	25	97	70
7	31	19	8	19	95	54
10	24	14	6	14	93	20

and the beta ray one farther away, there will be found pairs of distances for which the distributions for the two will be nearly the same. It is very difficult to make accurate measurements of these depth doses within the first centimeter of tissue, and in the subsequent discussion it must be borne in mind that the values given are not exact. However, no conclusions will be drawn which might be invalidated by more accurate information on this matter. Within the limits of our measurements it was found that when the gamma ray source was used at a distance of 5 mm. from the skin, and the beta ray source at 40 mm., the distribution of the two types was approximately the same. Accordingly the experiment was repeated with these distances—combination No. 2 of Table I. The result obtained was identical with the first. That is, for these two types of radiation, whether the sources are at the same distance or at such distances that the distribution of radiation in the first centimeter is substantially the same, it requires one-third more of a half-and-half combination of the two to produce an erythema than of either one alone.

In the third combination the distributions were different again, but in a direction the reverse of the first case. That is, in the first series a greater percentage of the harder radiation reached a depth of 1 cm. in the tissue, while in the third a greater percentage of softer rays reached this depth (due to the greater target-skin distance). Yet here again the same increase in threshold erythema dose for the combination was found. A similar situation was found in the fourth combination. In this case, as in all the others, the dose for the combination was one-third more than for either radiation alone.

Table II shows the distribution of these various types of radiation in the first centimeter of tissue, as determined by ionization measurements.

It must be remembered, however, that the quantities of radiation necessary to produce these erythemas were equal not from the point of view of ionization measurements, but from that of the skin reaction. This reaction does not occur on the surface of the skin, but at some finite depth—or depths—within it. It is doubtless not a simple reaction, but a summation of several different effects upon several different types of cells. However, for the present, we may assume that, whatever effects are summed, they become evident at the level of the pigment cells, and that these are at an average depth of 2 mm. in the skin. That is, the level at which all the radiations deliver 100 per cent should not be at the surface, but at a depth of 2 millimeters. In this case the values given in Table II would not represent the effective distribution, but this would be more closely approximated by those of Table III. However, this does not at all alter

TABLE III

DISTRIBUTION OF VARIOUS TYPES OF RADIATION IN FIRST CENTIMETER OF TISSUE—ON ASSUMPTION THAT EQUAL AMOUNTS ARE DELIVERED AT A DEPTH OF 2 MILLIMETERS

Depth in Tissue mm.	Percentage of Radiation Delivered at Depth					
	I	II	III	IV	V	VI
	Gamma Rays at 10 mm.	Gamma Rays at 5 mm.	Beta Rays at 10 mm.	Beta Rays at 40 mm.	X-rays Hard	X-rays Soft
0	145	175	260	195	101	111
1	120	130	160	140	101	108
2	100	100	100	100	100	100
3	83	81	67	77	99	94
5	61	53	36	49	98	78
7	45	33	21	37	94	50
10	35	25	15	27	92	22

the fact that it takes one-third more of any combination to produce the erythema than of either component of the combination.

There seems to be no physical explanation of this phenomenon. We have estimated the quantity of radiation delivered at different levels in the first centimeter of tissue by 135 per cent of the combinations tested, in comparison with that delivered by 100 per cent of the individual components, with the results shown in Table IV. In this table the first column specifies the individual radiation, the second gives the percentage arriving at the stated depth, if 100 per cent arrives at a depth of 2 millimeters. The third gives two-thirds of this value, which is the quantity of that type of radiation used in the combination. In the fourth column is the total amount of radiation from the combination indicated. The fifth and sixth columns show the ratios of the amount of combined radiation to that of gamma alone (which occurs in every combination) and to that of the second radiation of the pair, respectively. From these two columns it is evident that the amount of radiation delivered by the combination at any level within the first centimeter of tissue is always considerably more than that delivered by the less penetrating of the two components, and equal to or more than that delivered by the other, within the limits of experimental error. In other words, at any level within the first centimeter of tissue, there is definitely more radiation delivered by 135 per cent of any of the combinations studied than by 100 per cent of either component of that combination.

The actual tissue change which occurs, however, is probably not a simple reaction on pigment cells at a certain level in tissue, as we have supposed, but something much more complicated. Miescher (5) in an extensive study of radiation effects on skin, describes several varieties of cell change which occur. Different types of cell are affected in different ways. These reactions may be due to effects of radiation on different parts of the cell, or of different types of radiation on the same part. The observed skin erythema is the visible evidence of the summation of all these effects, and this visible effect may be reached by various summations. Evidently, then, the reaction for the combination may be really quite different from that produced by the single radiations. In view of the data of Table IV, some such interpretation of the phenomenon seems necessary. Definite information on the matter could not be obtained without extensive microscopic studies of irradiated skin.

It appears, from the evidence presented thus far, that the increased tolerance of the skin to combined radiations is real, and not based on any failure to interpret physical

TABLE IV

QUANTITIES OF RADIATION REACHING DIFFERENT DEPTHS IN TISSUE FOR DIFFERENT TYPES OF RADIATIONS USED SINGLY OR IN COMBINATIONS OF EQUAL PARTS OF TWO TYPES

Radiation	Per Cent at Depth for 100 Per Cent Dose	Per Cent at Depth for 67 Per Cent Dose	Per Cent at Depth for Combination	Ratio % for Comb. / % for Gamma	Ratio % for Comb. / % for Beta or X-rays
2 Millimeter Depth					
All types	100	67	134	1.34	1.34
5 Millimeter Depth					
Gamma—10 mm. Beta—10 mm.	61 36	41 24	65	1.06	1.81
Gamma—5 mm. Beta—40 mm.	53 49	36 34	70	1.32	1.43
Gamma—10 mm. Hard X-rays	61 98	41 66	107	1.76	1.09
Gamma—10 mm. Soft X-rays	61 54	41 36	77	1.26	1.43
10 Millimeter Depth					
Gamma—10 mm. Beta—10 mm.	35 15	24 10	34	0.97	2.26
Gamma—5 mm. Beta—40 mm.	25 27	17 18	35	1.40	1.30
Gamma—10 mm. Hard X-rays	35 92	24 62	86	2.46	0.94
Gamma—10 mm. Soft X-rays	35 22	24 15	39	1.12	1.77

differences. Therefore, as just suggested, a biological explanation must be sought. That is outside the scope of the present paper. We feel that we have answered in the affirmative the first question propounded—"Does the skin actually tolerate more radiation when combinations of different types are used?"

We have found little information in the literature on careful observations of skin reactions with combined radiations, except in the case of X-rays and ultra-violet rays, which we will consider later. Widmann and Weatherwax (6) report observations on 217 cases treated clinically with combinations of two types of X-rays or with gamma rays and X-rays. They found that it required amounts varying from 130 to 155 per cent of the combinations to produce erythemas. The reddening they observe is more intense than our threshold erythema, and their doses are determined by ionization measurements rather than by the erythema itself, so that it is not possible to compare their results directly with ours. However, their data offer a qualitative confirmation of our finding of increased skin tolerance with combined radiations.

As we stated at the beginning of this paper, the question of the advantage of using combined radiations is only half answered when we have found that the skin will actually tolerate more radiation when it is administered in this manner. It is also necessary to know if the tumor will tolerate more. We have no information on this subject. It appears that the erythema is a complex reaction, due to several effects on several kinds of cells. If the tumor reaction is also complex, we might expect it to act in a similar way to the skin. If, on the other hand, it is a simpler phenomenon, then it

might be expected to respond to the combination as to an actually increased dose of radiation. The question is one which can be settled only by extensive biological and clinical research.

Up to this point we have not discussed the results of our experiments with ultra-violet radiation. This is for two reasons. A glance at Table I will show that this combination did not give the same results as all the others. Moreover, we know very little about the absorption of this radiation in the tissues, and could not include it in any comparisons. As a matter of fact, when we included this combination in our series we were conscious that we were entering an entirely different field, but we were interested to see if a radiation so very different from the penetrating types already studied could follow the same law. When we found that, instead of obtaining our erythema with an increase of one-third in the dose, there was no visible effect with an increase of one-half, there seemed no immediate reason for going on and finding the actual dose necessary. We have found that the effect of ultra-violet and X-rays combined is different from that of X-rays and radium rays, in that it takes considerably more of this combination to produce an erythema. From a clinical standpoint there would be no advantage in using ultra-violet in deep therapy, in such combinations as we have been studying.

It may be of interest, however, to mention certain facts we observed in the course of this study. The individual reactions to ultra-violet rays were found to be much less regular than to radium or X-rays. Although the threshold erythema dose was determined by an average of about seventy-five tests on twelve individuals, there was quite a large range in the actual erythema doses for these persons. For a satisfactory experiment it was necessary to find the erythema dose for each subject separately. This was not the case with the other types of radiations. In earlier skin erythema experiments (*7*) we made a practice of testing each patient with a standard erythema dose, and found that over 90 per cent responded to it in a uniform manner.

In administering the combined treatment in this series the question arose as to whether the two types of radiation should be used at the same time; as in all the other combinations, or whether the ultra-violet should be used at the time when the reaction was to be expected from the X-rays—two weeks later. The observed reaction in the case of radium and X-rays is a secondary effect, the primary erythema being ignored in these cases. But ultra-violet radiation does not produce this secondary effect, and if a reaction is to be observed it must be a primary one. From this point of view it would be reasonable to apply the ultra-violet two weeks after the X-rays. But in all the other experiments the two types had been given consecutively, with no lapse of time. Therefore we decided in each patient for this group to give 75 per cent of the X-ray dose to each leg, followed immediately by 75 per cent of the ultra-violet to the right, while the ultra-violet to the left was given two weeks later. Six patients thus treated showed no reaction whatever at any time on either leg. Two others were supposed to be in this series, but in their cases the ultra-violet treatment actually produced a faint erythema, so that their doses of combined radiations were really about 175 per cent. In both of these, the leg which had the X-ray and ultra-violet together showed a faint flush in 24 hours over the whole ultra-violet area, 5 cm. square, with more intense color in the 3 cm. square area which had both radiations. In 48 hours all trace of the reaction was gone, but in two weeks there was a faint bronzed area in the 3 cm. square. The leg which had the X-ray alone at first showed no reaction at any time until the

ultra-violet was used, two weeks later. The day after that a faint erythema from the ultra-violet, with a deeper color in the center area of combined radiation, was observed. A week later—three weeks after the first exposure—both areas of combined radiation showed a faint tanning, but no further evidence of the ultra-violet was visible.

These two cases are too few to warrant any very definite conclusions. However, in view of the fact that it has been stated that ultra-violet rays act as an antidote for excessive X-radiation, the result is interesting. Sampson (8) first published this observation, and a number of clinical reports since have tended to establish the idea. None of these were carefully observed experiments, but rather impressions. However, MacKee and Andrews (9) and Pfahler, Klauder, and Martin (10), in attempting to obtain confirmation of the theory, came out with experimental results which contradicted it. Our two cases indicate that, instead of increasing the resistance of the skin to X-rays, the ultra-violet radiation made it more sensitive, since in these cases three-quarters of an erythema dose of X-rays produced a visible reaction when used in conjunction with a very mild dose of ultra-violet rays.

SUMMARY

It is shown that, for combinations of gamma rays and hard beta rays, gamma rays and soft X-rays, and gamma rays and hard X-rays, in equal parts, it requires one-third more radiation to produce a threshold erythema on human skin than for any of these types used alone.

This increase is real and not based on a misinterpretation of readings of physical instruments. The quantity of radiation was not measured by any instrument, but by its effectiveness in producing the skin erythema.

No physical explanation can be offered for the phenomenon.

In the case of a combination of equal parts of ultra-violet and soft X-rays, the erythema was not produced with an increase of one-half in the dose, under the conditions described.

The authors wish to express their gratitude to Mr. L. Marinelli, who made many of the tests with soft X-rays. They also wish to thank Dr. G. Failla for his interest and helpful suggestions during the course of the work.

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DISCUSSION

DR. FRANCIS CARTER WOOD (New York): This paper of Dr. Quimby's is, I am sorry to say, a rare exception to most of the papers we hear. It is sound both physically and biologically, and she has taken into consideration all possible conditions which apply. Now there cannot be any challenge to her facts; that is obvious. The work has been so painstaking and so thorough that the proof that two erythemas do not amount to 50 and 50 per cent is obvious. Of course, as I pointed out last year, the sum of 50 per cent of a lethal dose of radium and 50 per cent of a lethal dose of X-ray on *Drosophila* eggs comes to 100 per cent, and with extraordinary accuracy. Now that only means that this is true for a very minute group of individual cells, and it gives point to my previous remarks, that the question of an erythema dose is not a matter of physics but of clinical observation. However, it is unquestioned that this 50 and 50 per cent sum is true in tissues for the individual cells, but whether, as Dr. Quimby has carefully pointed out, a tumor will be destroyed more effectively by a combination of 50 per cent and 50 per cent, is not answered by these experiments on isolated eggs of the *Drosophilas.* It is answered only for the individual cell of the tumor, but not the tumor *en masse,* and whether the tumor will be better killed as a gross object by radiation of half X-ray and half radium is again a clinical matter for clinical investigation; it cannot be answered abstractly. It may be that some tumors will disappear by half and half; it may be that the destruction of the tumor does not depend upon the grade of sensitivity of the individual tumor cell. It may be a fact that the very sensitive tumor cells are killed by a 50 plus 50 per cent dose and the very resistant tumor cells require the 135 per cent. That, again, is a purely clinical matter, and no answer can be made except by clinical experiments of the same type. Remember, these experiments are carried out with materials suspended in the air on very thin gauze, away from all scattering material; that all questions which are involved in the tissues, the type of scatter, the reaction which goes on in the individual protein molecule, the effect on the wave length, the hundred different things we can think of as playing a part—those questions cannot be settled by either the flies' eggs or by the study of the tissues at the present time. Tissue studies on the effect of radiation are, as a matter of fact, very unsatisfactory; they differ with different tissues and different tumors, and some of our tumors are killed by direct action and others by the interference with the circulation which the radiation produces. This is an interesting and valuable paper, which emphasizes the importance of the combination of careful physical and clinical observations. It does not invalidate at all the biological experiments, but only shows that in a complex organism we must be very careful about generalizations. I hope that Dr. Quimby will extend these studies to the very soft and very hard X-rays, making a combination of the two, but in all probability the answer will be the same, because she has used hard X-rays and gamma rays of a fifth—or whatever it may be—of the wave length of the X-ray which she has used, so I think the answer will be the same. I am not astonished that the ultra-violet was not at all consistent: ultra-violet action is molecular and not atomic, and while the mode of killing the cell may be the electrons discharged in the cells, that is something we do not know definitely. It would not be expected that the two reactions would be comparable; one is very superficial, and, also, the erythema with the ultra-violet varies with the pigmentation of the skin and, as you know, a patient easily acquires an immunity or resistance to the ultra-violet.

I hope that in a year or so Dr. Quimby will be able to give an answer from tests on

tumors. The great difficulty with experiments on human tumors is that no human tumor has the same X-ray sensitivity as any other human tumor. That is the advantage in using standard transplanted animal tumors.

DR. W. E. CHAMBERLAIN (San Francisco): Dr. Quimby's work is so careful and scientific as to seem conclusive. Yet, after reading her recent publication on this subject, and hearing this present paper, I am still unconvinced, and I am wondering whether it is possible to carry out such studies by attempts to estimate skin changes, *e.g.*, erythema. Dr. Quimby feels that through the use of many skins, a statistical type of answer has been obtained, of greater value than attempts to read shades of difference on one skin. This is doubtless correct. But in all attempts to determine presence or absence of erythema, it is fundamental that a slight change is recognizable only when it is bordered by sharply demarcated normal (unrayed) skin. An erythema which is readily discernible when sharply contrasted with surrounding protected skin, becomes entirely indistinguishable when situated in the center of a large irradiated area in which the intensity of the dose gradually fades off as one passes from center to margin. Dr. Quimby's radium applications must have given erythemas which faded quite gradually into normal skin, for it is impossible to obtain sharp margins when irradiating with gamma rays. Dr. Quimby now plans to carry out a further study of skin erythema with combinations of two types of rays, this time using hard and soft X-rays. In this study she will have sharply demarcated areas to observe, and I will be very much surprised if she does not find that a 100 per cent erythema effect is obtained when a 50 per cent dose of soft X-ray is added to a 50 per cent dose of hard X-ray.

And I am tempted to ask, "How could it be otherwise?" When one reviews the work of Holthusen, Francis Carter Wood, and others, proving that air ionization and biologic effect are parallel for even grossly different qualities of ray; and when one visualizes the number of different wave lengths that are present in many of the beams that these workers used, it seems quite inevitable that the addition of half doses of two X-ray beams, however dissimilar, must produce exactly one full dose in effect, no more, no less.

DR. G. FAILLA (New York): I think I shall take this opportunity to assure Dr. Wood that I do not question the results which he and Dr. Packard have obtained in their work with *Drosophila* eggs. I believe, on the contrary, that these results are the most accurate which have ever been obtained in work of this sort. However, I do not think that we are justified in generalizing from these results and concluding that all biological effects are independent of the wave length of X-rays.

Mrs. Quimby has presented today some very interesting results, which show that the wave length or combination of wave lengths has a marked effect on the production of skin erythema. She has said (and I agree with her) that there is apparently no *physical* explanation for these results; accordingly they must be accounted for on a biological basis. If, now, we assume with Dr. Wood that biological effects are independent of the wave length, the explanation of Mrs. Quimby's results becomes even more difficult. Personally I have no predilection for one theory or another. I am simply waiting for sufficient experimental evidence before formulating any theory. With all the work on this question which is being done in different laboratories, I believe that it will not be very long before this point is settled to the satisfaction of all concerned.

DR. QUIMBY (New York): Dr. Wood has asked me about the relative times of exposure for the different types of radiation. We attempted to adjust our intensities of radiation so that the times would be approximately the same, in order to avoid possible errors from such a variation. It was not possible to do this exactly, but the shortest exposure used was about half an hour and the longest about two hours. This holds for both combined and single types.

I am exceedingly interested in Dr. Chamberlain's results. We have not been able to try the combination of hard and soft X-rays, but I do not believe that the discrepancy between his results and ours is due to inaccuracy in reading the erythemas. It is quite true that it is more difficult to read the radium erythemas than those due to X-rays, but it becomes easier with experience. We tried to eliminate any possible errors in deciding whether erythemas existed. Dr. Pack and I made our observations independently, but our decisions were almost always in accord. I kept the records and knew the doses which had been administered, which might have prejudiced my judgment, but Dr. Pack never knew at the time he examined a patient what the latter's treatment had been. In a few cases it was impossible to be sure of the result, due to some skin condition (blotchiness, hairiness), and these have been omitted from the data. I hope we may be able to repeat Dr. Chamberlain's work and either confirm his results or find out why ours do not agree with his.

A SIMPLE SELF-RECTIFYING GAS X-RAY TUBE

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THIS tube was originally developed because of the need in some biological experiments for a constant and more intense source than is given by the commercially available X-ray tubes. It has proved to be so simple and reliable in everyday operation, however, that in this laboratory it has replaced commercial tubes for the preparation of the different kinds of photographs used in crystal analysis.

Self-rectifying gas tubes have been made familiar to many through the Shearer tube, as manufactured by the firm of Adam Hilger. There is, however, a wide range of tube dimensions over which self-rectification can be obtained. The amount of high voltage current which a tube will pass unilaterally depends upon its total volume, the size of its cathode, the shape and size of the anode end and other details of its design. A number of forms have been made and tried out in this laboratory. The one to be described is undoubtedly not the best possible, but it has fulfilled our requirements sufficiently well to make further studies unnecessary at this time. The tube has two advantages over the usual type: it is much simpler and cheaper to make; at the same time, it seems from our experience to give steadier operation with a more intense useful beam.

A gas tube was adopted only after long experience with hot cathode metal tubes. Where, as in crystal analysis, purity of spectrum is important and a metal tube is to be in daily use, it has been found easier to build a controllable gas tube than to prevent tungsten sputtering in one of the electron type.

A photograph of the tube is shown in Figure 1. Drawings of the essentials of its construction are reproduced in Figures 2-*A* and 2-*B*. It is composed of three parts, the anode end, A, with target, *a*, the cathode C and the glass tube B which serves to connect the two ends while keeping them insulated from one another.

Except for the water jacket, *j*, and the removable target, *a*, the anode end is machined from a single piece of solid brass rod. Into this is threaded and soldered the pump connection *b*. The cap, *c*, projects into the glass, B, and protects a section of it from sputtering. Flat places, *d*, are machined on either side of the anode block and holes, *e*, cut to provide windows for the emitted X-rays. In tubes for structure analysis these windows have been rectangular, as in Figures 2-*A* and 2-*B*; for some biological irradiations they have been circular with a diameter of 5/16 inch. They have been covered with 0.001 in. aluminum foil which inspection showed to be free from holes. Care must be taken in mounting these windows to be sure that the cementing wax holds the foil smoothly and tightly. If the smallest bits of wax or dirt get inside the tube, it will be erratic in operation until cleaned. Furthermore, if wax gets unevenly under the windows, they will crack and develop leaks as the tube is successively exhausted and filled with air. Hard de Kotinsky cement or white wax has proved best for these seals. Imperfectly made windows, in our experience, account for a majority of the difficulties with these X-ray tubes. The anticathode, *a*, is a hollowed-out, water-cooled brass rod threaded into the anode block. The metal to serve as anticathode is either silver soldered or spun into its face, *f*. It is convenient to have several targets faced with different metals which can be used interchangeably. The seal is effected by filling the cup *g* with a suitable wax. Black piceïn, as a relatively soft wax which

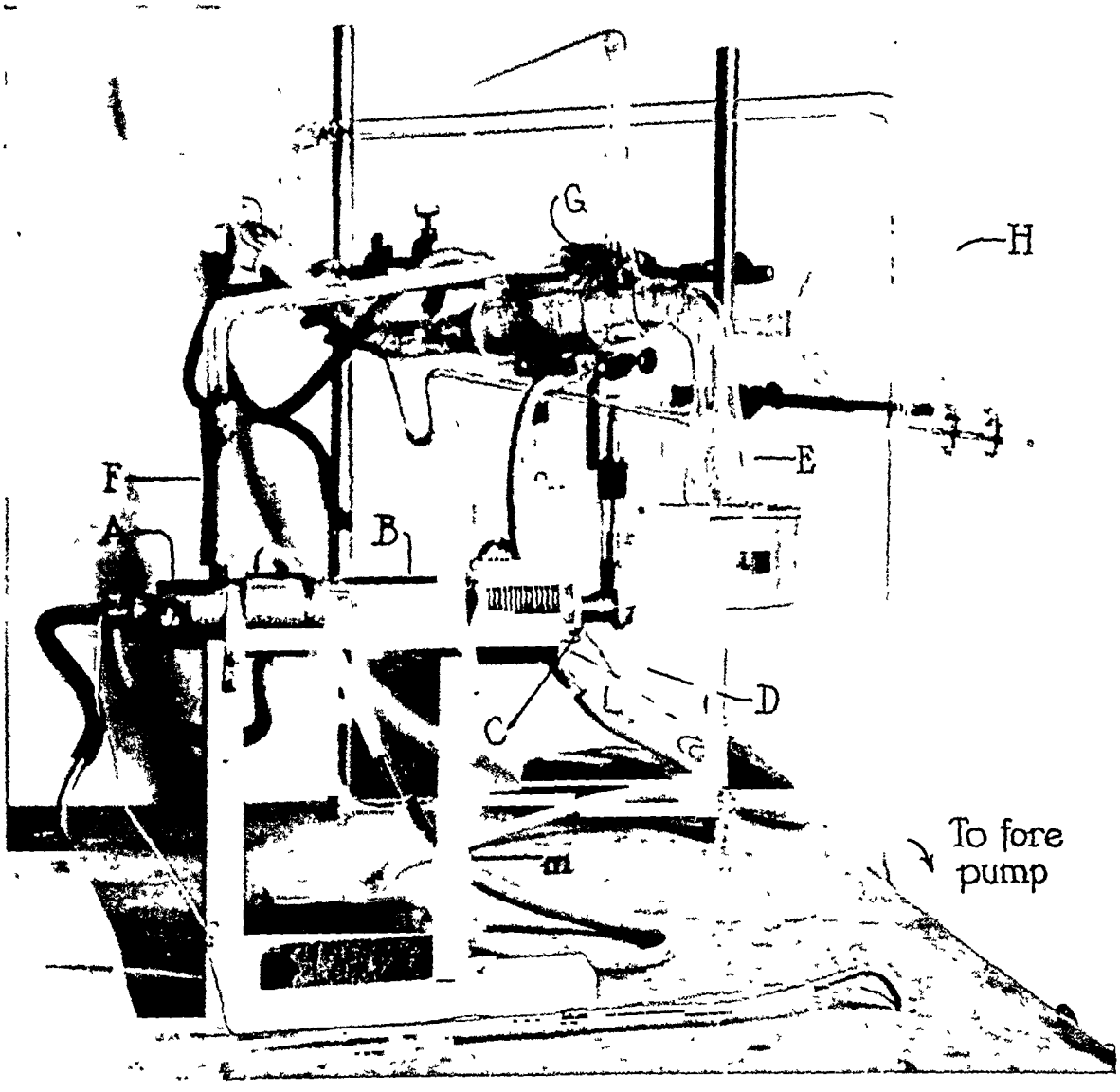
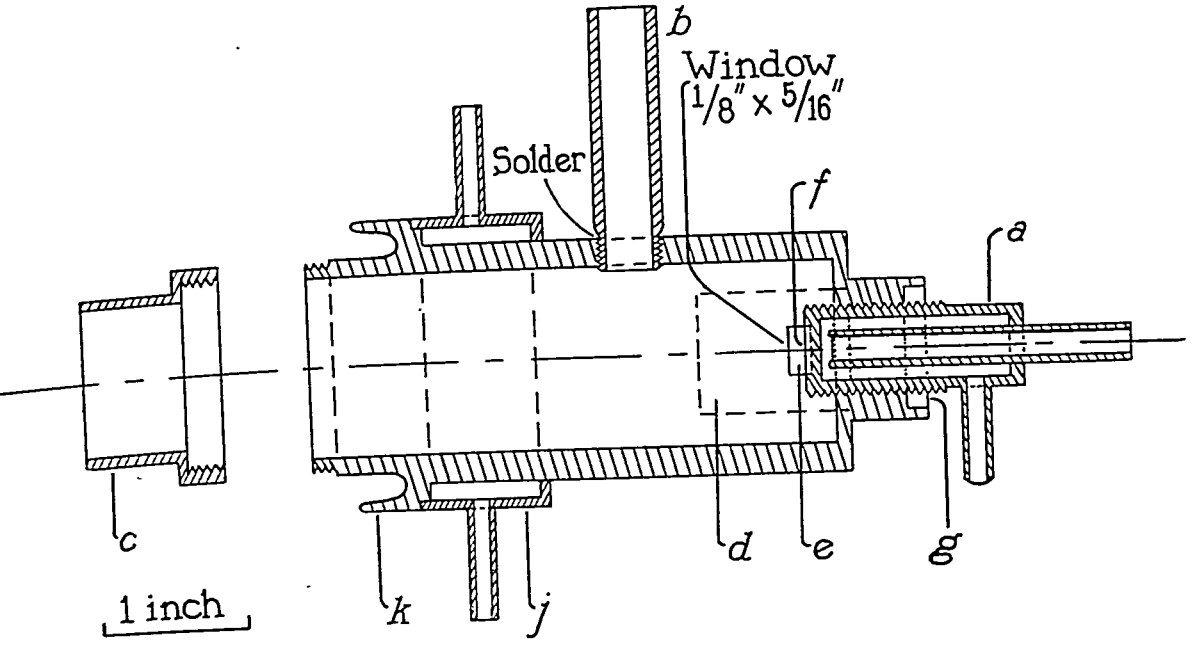
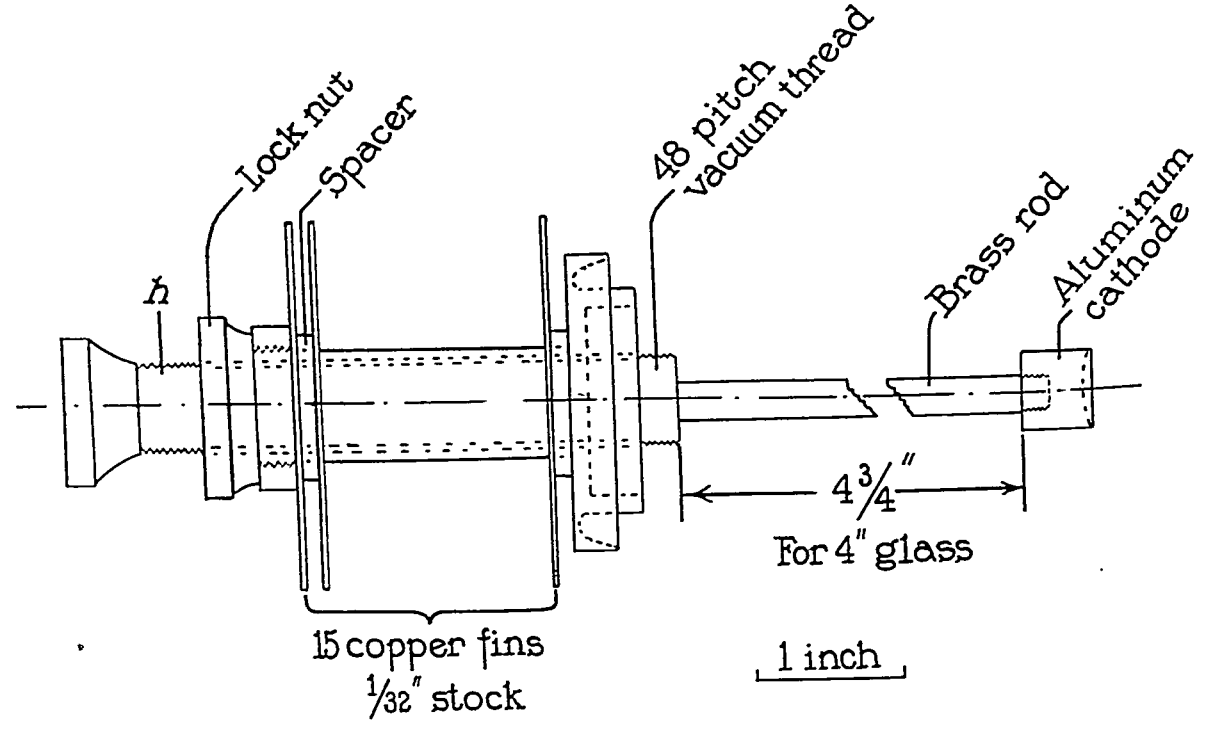


Fig. 1. A photograph of the X-ray tube and its evacuating system. (See Figures 2-*A* and 2-*B*.)

wets brass well, is very satisfactory for this joint. In some early tubes the anticathode was carried on a carefully made and greased vacuum thread. Owing to the difficulty of keeping the interior of the tube free from traces of grease, this construction is not to be recommended.

Except for the cathode piece itself, which is of aluminum, and the radiating copper fins, the cathode is of brass. After long use the aluminum end, which should be slightly concave, may become so pitted as to need refinishing. The size of the focal spot will depend upon the distance between target and cathode (ca. 1.75 in.). In order to be able to adjust this focus without destroying the vacuum in the tube, the cathode is mounted on the vacuum threaded screw *h*. When well made and lubricated with a good rubber grease, this thread is completely vacuum-tight. The connecting pyrex glass tube, B, is about four inches long for voltages up to 40,000 volts; with higher voltages a six-inch tube has been used. During operation





Figs. 2-*A* and 2-*B*. Drawings of the essentials of construction of the X-ray tube. The anode end is shown in 2-*A* (*above*), the cathode in 2-*B* (*below*).

this glass will become warm. On account of the resulting temperature difference between it and the water-cooled metal end at *k*, a joint made of the best quality red sealing wax is superior to de Kotinsky cement.

In order that apparatus may be brought close to the target, only the cathode is maintained at high potential. Adequate electrical insulation is obtained by making the support *m* of Figure 1 from hard rubber.

For voltages at least as high as 60 K.V. this tube gives perfect self-rectification with currents of 10 milliamperes. We have not sought to use higher voltages nor have greater current inputs been tried for. In trial runs currents as high as 20 ma. have been used satisfactorily for short periods but for continuous service at such energy consumption the windows should be water-cooled. In routine work we use a current of ca. 5 ma., with a voltage of ca. 40 K.V. This output is set not by the capacity of the tube but by the fact that it gives sufficiently short exposure times and by the belief that the dangers to the experimenter from the stray radiation with stronger beams are not worth the convenience of still quicker photographs. The beam from a copper target obtained under the foregoing conditions will kill in 20 seconds half of the bacteria it strikes at a distance of two inches from the window and would produce corresponding injury to other living cells in its path. It is obvious that unless care is taken the operator may be seriously injured by these rays. With a good and large crystal such as calcite, a satisfactory 30° oscillation spectral photograph can be made in from one to two minutes; only rarely do the exposures for small crystals or poorly reflecting faces exceed one hour.

THE VACUUM SYSTEM

For the satisfactory operation of a gas tube the evacuating system is as important as the tube itself. Since the output of X-rays depends on the gas pressure, some device must be used to hold this constant. If a steady output is not desired, one of the several sorts of slow gas or air leaks that were developed for early X-ray tubes could be employed. It is as easy and much more satisfactory to make use of a pressure regulator. Several[1] have been suggested. Each is a valve placed between the tube and the vacuum pump and actuated by a solenoid through which flows current from the primary of the high tension transformer. When the gas pressure in the tube rises, more current is consumed. Acting through the solenoid, this increased current opens the valve and allows the pump to exhaust the tube till the pressure has fallen to its previous level. A drawing of the regulator we use is shown in Figure 3. In the photograph (Fig. 1), it is to be seen at D between the tube and the mercury pump E. The iron core, *n*, floats on the surface of mercury. When lifted by the solenoid the mercury level in *p* drops and connection is established between *q* and *r* through slots,[2] *w*. The tube current regulated in this way is approximately adjusted by raising and lowering the iron cap, *s*, using the vacuum threaded screw, *t*. Accurate setting is effected by altering the current through the solenoid, which is connected in parallel with a variable resistance in the primary circuit of the transformer. The pull on the core may be varied by changing the height of the solenoid. When trial has shown the most sensitive position, it can be held in place with a ring of insulating tape wound around the glass tube. The characteristics of a suitable electrical circuit are shown in Figure 4.

The stopcock *u* is left open while the system is pumping to about the desired pres-

[1] R. M. Bozorth, Jour. Am. Chem. Soc., 1927, XLIX, 971; F. E. Haworth, Jour. Opt. Soc. Am., 1929, XIX, 79; T. N. White, Jour. Sci. Inst.

[2] T. N. White, *op. cit.*

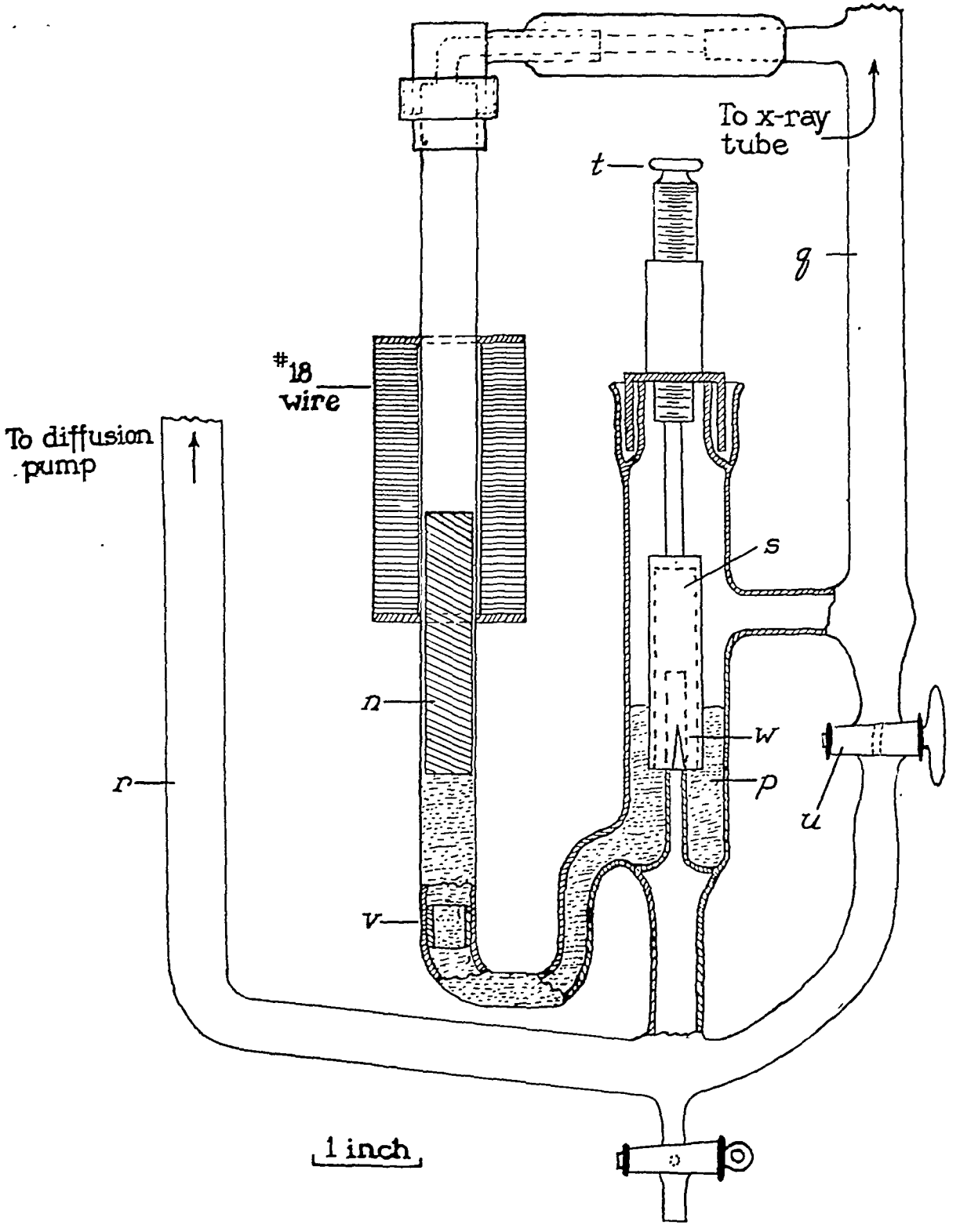


Fig. 3. A drawing showing details of the gas pressure regulator D of Figure 1.

sure; during operation it is closed. If small particles of grease or dirt accidentally get into the X-ray tube, the consequent large and erratic evolution of gas may cause the iron core to jump violently. To prevent breakage of the containing arm, a carefully cleaned piece of rubber tubing is shellacked into place at v to serve as a bumper.

In breaking in a new tube, it is best to evacuate it till it is completely hard and then to raise the voltage by steps till no current is passed, even momentarily, at the highest potential to be used. For 60 K.V. this should not take more than ten or fifteen minutes if the tube is clean inside and its seals properly made. The voltage should then be reduced to a low value, the stopcock u closed and the screw t manipulated to allow the tube gradually to soften. As soon as it begins to pass rectified current, as indicated by the milliammeter, the voltage should be raised slowly to the desired value. Frequent use of the stopcock probably will be needed to control the gas pressure until adjustment has been made for the current and voltage to be used. If the tube and system are tight, the whole procedure should not require more than half an hour. We follow the same general routine of complete evacuation and slow raising of voltage every time the tube is to be used. As long, however, as the output is not to be changed, the screw, t, need not be adjusted and ordinarily the tube is ready for use within ten minutes of the time the pumps are started.

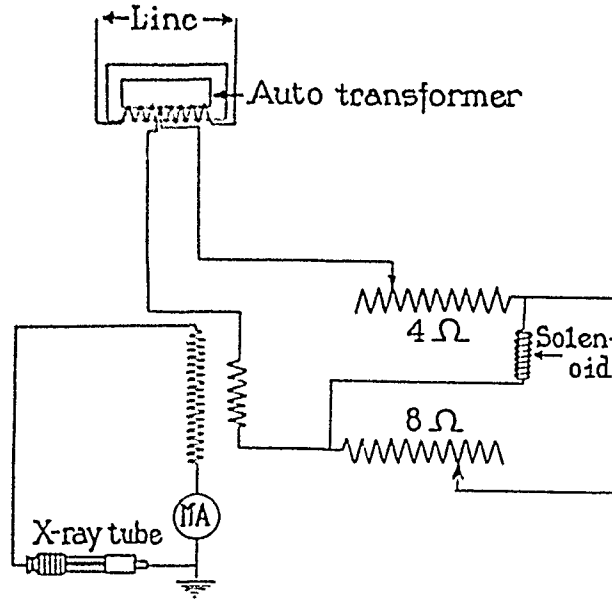


Fig. 4. An electrical circuit suitable for the operation and control of the X-ray tube.

For steadiest operation it is better not to have the system absolutely tight. Satisfactory results have been obtained by introducing a pair of rubber junctions of nitrometer tubing at F and G of Figure 1. The glass-rubber and metal-rubber surfaces are shellacked but the rubber itself is not painted. The consequent flexibility makes connection of the tube easy and the rubber seems sufficiently porous to give a suitable leakage of air. If the mercury pump is fast, it is perhaps better to increase the volume by introducing a flask such as H.

Where a very steady output is desired, a controllable air leak may be added and a mercury trap cooled in alcohol and solid CO_2 interposed between diffusion pump and tube. With this arrangement a tube will operate day after day for hours at a time

with a maximum current fluctuation of ca. 0.1 ma., provided occasional adjustment is made of the solenoid rheostat to take care of gradual hardening after evacuation. When equal voltages are maintained across a tube and equal currents through it, ionization measurements with an air chamber made on successive days have been found constant within the accuracy of the method (ca. 2–3 per cent).

ANALYSIS OF DIAPHRAGM SYSTEM FOR THE X-RAY STANDARD IONIZATION CHAMBER[1]

By LAURISTON S. TAYLOR, Bureau of Standards, Washington, D. C.

IN measuring the ionization in an *unrestricted volume of atmospheric air*, according to the internationally adopted definition of the r-unit,[2] the accuracy of the determination depends principally on, first, the electrical measurements of the ionization and control of the X-ray output; secondly, the determination of the air volume of which the ionization is being measured. The first has been treated by Behnken,[3] Glasser,[4] Duane,[5] and more recently by the author;[6] the second is effectively the object of the present paper.

Behnken,[7] in a comparison of the r-unit between the laboratories of Glasser, Duane, Grebe, Küstner, Holthusen, and the Physikalisch-Technische Reichsanstalt, found a 4 per cent discrepancy among the different laboratories. In his publication of the results of this comparison no explanation is offered for the disagreement, it being assumed to be due to faulty experimental technic rather than to the theory of the experiment. In a study by the author[8] of the various measuring methods, a source of error sufficient to account for Behnken's results was traced to the measurement of the ionization current. However, it is recognized that even an agreement between two laboratories might arise from the errors present compensating each other, so that it is very desirable to study the possible errors in the various other controlling factors.

In practice, the ionization is measured in several cubic centimeters and the ionization current divided by the corresponding air volume, the ionization throughout the entire volume being assumed to be uniform. However, this is not, in general, the case, and so we must determine the effective volume corresponding to uniform ionization. In some recent work Failla[9] has measured air ionization in a standard chamber, using widely varying diaphragms, and found that, according to the particular diaphragm system used, there may be a considerable uncertainty in the determination of the air volume.

Behnken, Glasser, and Failla have used circular diaphragms of the order of 1 cm. diameter, while Duane uses a rectangular slit system where his chamber diaphragm is 0.5 by 5.0 centimeters. Most of the observers have placed a screening diaphragm close to the tube to prevent radiation from the target stem entering the standard chamber. Depending upon its relative size and position with respect to the focal spot, this diaphragm may or may not have a direct bearing on the ionization readings.

It, therefore, seemed advisable to analyze the effects of the diaphragm system carefully so as to obtain some quantitative measure of the error introduced by certain assumptions regarding it. We shall, therefore, treat the problem, first considering the focus as a point source (Sec. II, 1), then as an extended source (Sec. II, 2), and finally show

[1] Research Paper No. 119. Reprinted from *Bureau of Standards Journal of Research*, November, 1929, III. Reprinted by permission.

[2] The r-unit is defined as "the quantity of radiation which, when the secondary electrons are fully utilized and the wall effect of the chamber is avoided, produces in 1 cubic centimeter of atmospheric air at 0° C. and 76 cm. mercury pressure such a degree of conductivity that one electrostatic unit of charge is measured at saturation current."

[3] Behnken, Hermann, and Jaeger, Robert: Ztschr. f. tech. Phys., 1926, VII, 564.

[4] Glasser, O., and Portmann, U. V.: Am. Jour. Roentgenol. and Rad. Ther., January, 1928, XIX, 47.

[5] Duane, William, and Lorenz, Egon: Am. Jour. Roentgenol. and Rad. Ther., May, 1928, XIX, 461.

[6] Taylor, L. S.: Bureau of Standards Journal of Research, 1929, II, 771.

[7] Behnken, Hermann: Strahlentherapie, 1928, XXIX, 192.

[8] See Footnote 6.

[9] Failla, G.: Am. Jour. Roentgenol. and Rad. Ther., January, 1929, XXI, 47.

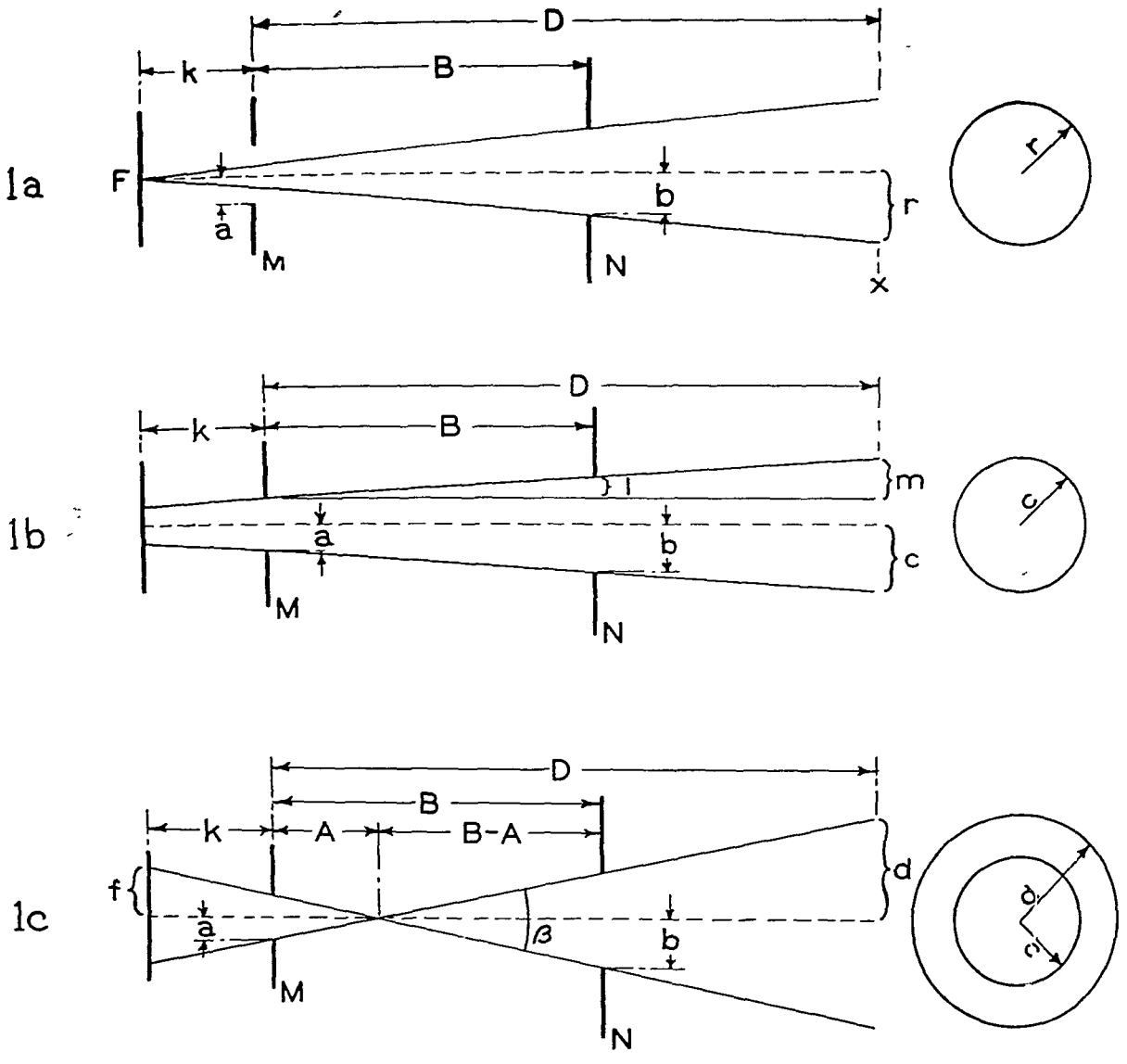


Fig. 1. Diaphragm system.

the experimental justification (or failure) for the assumption made (Sec. III, 2).

II. GEOMETRICAL ANALYSIS OF THE DIAPHRAGM SYSTEM

1. Behnken's analysis, assuming a point source of radiation.—In this it is assumed that the focus is a point source of radiation, and that the X-ray flux density is uniform over the cross-sectional area of the beam in the ionization chamber. When the diaphragms are very small compared with their separation, these two assumptions may be considered valid; but, in general, they are contradictory, since the radiation from a point source gives a flux density in the direction of the beam which is proportional to the cosine of the angle that the given ray makes with this axis.

In presenting Behnken's analysis,[10] we shall use for ease in the later development a nomenclature differing slightly from his. Referring to Figure 1 (*a*), *F* is the focus of the X-ray tube, *M* the first diaphragm, radius *a;* *N* the ionization chamber dia-

[10]Behnken, Hermann: Strahlentherapie, 1927, XXVI, 79.

phragm, radius b, and x a plane in the ionization chamber normal to the axis of the beam.

The focus is assumed to be a point, the X-ray intensity of which is represented by a flux density of I_o at unit distance. Then on the axis of the beam at x, the intensity, or flux per unit area, is given by

$$I_x = \frac{I_o}{(D+k)^2} \qquad (1)$$

provided, of course, that the radiation be sufficiently penetrating to permit loss by absorption in the length $(D+k)$ to be neglected. Letting r equal the radius of the cross-section of the beam at x, we see that

$$\frac{r}{b} = \frac{D+k}{B+k}$$

so that the cross-sectional area of the beam at x is

$$\pi r^2 = \frac{\pi(D+k)^2 b^2}{(B+k)^2} \qquad (2)$$

The volume of an element of length dx of the beam is $dV = \pi r^2 dx$. The energy dE absorbed therein per unit time is

$$dE = \varkappa I_x dV \qquad (3)$$

where $\varkappa$ is a constant. The number of ions produced by this absorbed radiation being proportional to dE, the electrical measurement of the ionization gives a quantity proportional to the X-ray intensity I_x.

From the equations (1), (2), and (3) above we find that the energy absorbed in the element at x is

$$dE_1 = \frac{\varkappa I_o}{(D+k)^2} \cdot \frac{\pi(D+k)^2}{(B+k)^2} b^2 dx \qquad (4a)$$

$$= \varkappa \frac{\pi b^2}{(B+k)^2} I_o dx \qquad (4b)$$

Equation (4b) expresses, however, the energy absorbed in a volume of cross-sectional area πb^2 and thickness dx, located at a distance $(B+k)$ from the point source (that is, at the diaphragm N). Therefore, for any length L_o of the chamber, the total energy E_1 absorbed in the chamber is given by

$$E_1 = \frac{\varkappa \pi b^2}{(B+k)^2} I_o L_o \qquad (4c)$$

As a consequence we are justified in considering the effective air volume as having a radius b, a length equal to the effective length of the measuring electrode, and located at a distance $(B+k)$ from the focus. The question as to what part of the ionized air volume the distance must be measured, in applying the inverse square law, is thus answered. In a previous paper the author has given the necessary electrical conditions to determine accurately this effective length L_o of the air column from which the ionization is being measured.

2. *Analysis assuming an extended source of radiation: (a) general treatment.*—Mayneord[11] and others have considered the focus as an extended source, but exaggerated, as shown below, the importance of the error introduced by assuming a point source. To estimate this error another assumption will be made which, while not quite correct, is indicated by experimental evidence to be a closer approach to the true conditions.

Consider the focus to be an extended source having an area at least as great as the projected area of the diaphragm N upon the target. (Fig. 1 (*c*).) Let, further, the "brightness" (in the optical sense) of the focal spot be uniform both as to area and direction viewed. Then over the plane x the distribution of flux density varies in a manner determined by the diaphragm system. There will be a *central area* of radius c (Fig. 1 (*b*)), having a nearly uniform distribution, and a surrounding *ring area* of outer radius d (Fig. 1 (*c*)), having a non-

[11] Mayneord, W. V.: Brit. Jour. Radiol., 1928, N. S. I, 125.

uniform distribution. Their dimensions are readily obtained.

To find the radius c of the central area, consider the system of Figure 1(b)

$$\frac{b-a}{c-a}=\frac{B}{D}$$

from which

$$c=\frac{Db-Da+Ba}{B} \qquad (5)$$

For the outer radius d of the penumbra, Figure 1(c) gives,

$$\frac{a}{b}=\frac{A}{B-A} \text{ or } A=\frac{Ba}{a+b}$$

also

$$\frac{B-A}{b}=\frac{D-A}{d}$$

whence

$$d=\frac{D-A}{B-A}b$$

substituting the value of A above

$$d=\frac{Da+Db-Ba}{B} \qquad (6)$$

It is seen that the values of c and d are independent of the distance k from the focus to the first diaphragm M, and, as experimentally demonstrated in Section III, 2, we are thus justified in considering the first diaphragm M, as the source of radiation, whose brightness is also, like that of the target, uniform with both direction and area for the small angles under consideration.

If now, the *aperture* of the system be defined as the solid angle β (Fig. 1 (c)) between the most divergent rays passing through the two diaphragms, we see that the first diaphragm may be considered as the source of radiation only if the actual area of the focal spot fills the aperture β of the system. This limiting condition is seen from Figure 1(c), where f is the radius of the focal spot. Its magnitude is taken from

$$\frac{f}{a}=\frac{A+k}{A}$$

from which

$$f=\frac{ka+kb+Ba}{B} \qquad (7)$$

by substituting the value for A as derived in Equation (6).

To determine the flux density at any point on the plane x due to the total emission from the focus, we may use the cosine law of emission and illumination as expressed by

$$dI_x=\frac{I_o\cos^2\alpha\ da\ dc}{D_{ac}} \qquad (8a)$$

where I_o is the flux density at the target in the direction along the axis of the beam and likewise also the corresponding flux density through the area at M; dI_x is the flux density through an element of area dc in the plane x, and in a direction normal thereto; α the angle which the line joining da and dc makes with the normal to these areas, and D_{ac} the distance between the elements. The total flux I_x at any point on the plane is obtained by integrating the flux received from the various elements of the surface πa^2 of the diaphragm M. This has been evaluated by Foote[12] for the illumination from a radiating disk.

If β_0 is the angle between the axis and the most divergent ray, then referring to Figure 1 (c), for $\cos^2\beta_0=0.9950$, $\cos\beta_0$ can be assumed equal to unity without introducing an error greater than 0.5 per cent in the flux density at any point. This condition is true for the experimental arrangement of most observers. With a system

[12]Foote, P. D.: Bureau of Standards Bulletin No. 263, 1916, XII, 583.

such as used by Duane, however, it is not negligible.[13]

In the case where $\cos^2 \beta_0 = 0.9950$, we may assume the flux density I_x uniform over the central area (Fig. 1 (*b*)) and given by

$$I_x = \frac{I_o}{D^2} \tag{8b}$$

where, since D is the distance from the plane x to the first diaphragm M, the effect at x is as if the source were located at the diaphragm M.

The energy dE_2 absorbed in the central volume element dv of cross-sectional radius c and thickness dx is then

$$dE_2 = \varkappa I_x dv$$

$$= \varkappa \frac{I_o}{D^2} \pi c^2 \, dx$$

$$= \frac{\varkappa \pi (Db - Da + Ba)^2}{B^2} \cdot \frac{I_o}{D^2} dx \tag{9a}$$

Like dE_1 in Equation (4a), dE_2 is proportional to the ionization current measured. In the special case where the two diaphragms are equal $a=b$ and thus

$$dE'_2 = \frac{\varkappa \pi b^2}{D^2} I_o \, dx \tag{9b}$$

It will be noticed that dE'_2 in Equation (9b) has the same form as dE_1 in Equation (4b), the only difference lying in the replacement of $(D+k)$ by D. It remains to determine the ionization in the penumbra, which may be neglected when using very small diaphragms very far apart, but not in general.

The ionization produced in a volume element of the surrounding ring area or penumbra of outer radius d can not be easily calculated, owing to the fact that from any given point on the ring only a fraction of the first diaphragm is visible. Thus, at the inner radius of the ring the X-ray flux density is equal to that of the inner area while at the outer edge it is zero.

(b) Effective volume of air ionized.—Having found the effect in the central area as above, one might proceed by using Foote's derivation to evaluate that in the penumbra, but a simpler and more direct method is suggested by the derivation above for the effect of a point source.

We proceed, therefore, to determine the total energy absorption within the chamber, regardless of its distribution. Since it is permissible to neglect the loss in flux arising from absorption along the path, it is obvious that the ionization in a length dx in any cross-section of the beam at any plane x within the ionization chamber is proportional to the total flux through that cross-section. This is given, however, by the total flux entering the diaphragm N. The combined result along any length L of the beam in the ionization chamber is equal then to that of a beam having a cross-section equal to that of the entrant diaphragm N and a total flux density equal to that at N. This gives for each element of length

$$dE_3 = \frac{\varkappa \pi \, b^2 \, I_o}{B^2} dx \tag{10}[14]$$

Summing up for the whole effective length L_o of the measuring electrode, we have

$$E_3 = \frac{\varkappa \pi \, b^2 \, I_o}{B^2} L_o \tag{11}$$

Equation (11) has the same form as that of Behnken, Equation (4c), the difference being in the location of the effective source of the X-radiation at the diaphragm instead of the focus.

We have thus established that for either

[13] It must be pointed out that the cosine law cannot be applied rigorously to X-radiation. However, by considering the energy distribution about an X-ray tube target, we see that over small ranges the error introduced by assuming this law is very small. If we consider the change in flux density over a plane, from a point or extended source, as due simply to the change in distance from the source, we arrive at an equation identical with Equation (8a).

[14] Equation (10) may also be obtained from Equation (9a) by the process of decreasing D until it is equal to B, at which point the penumbra disappears, with consequent simplification of the problem.

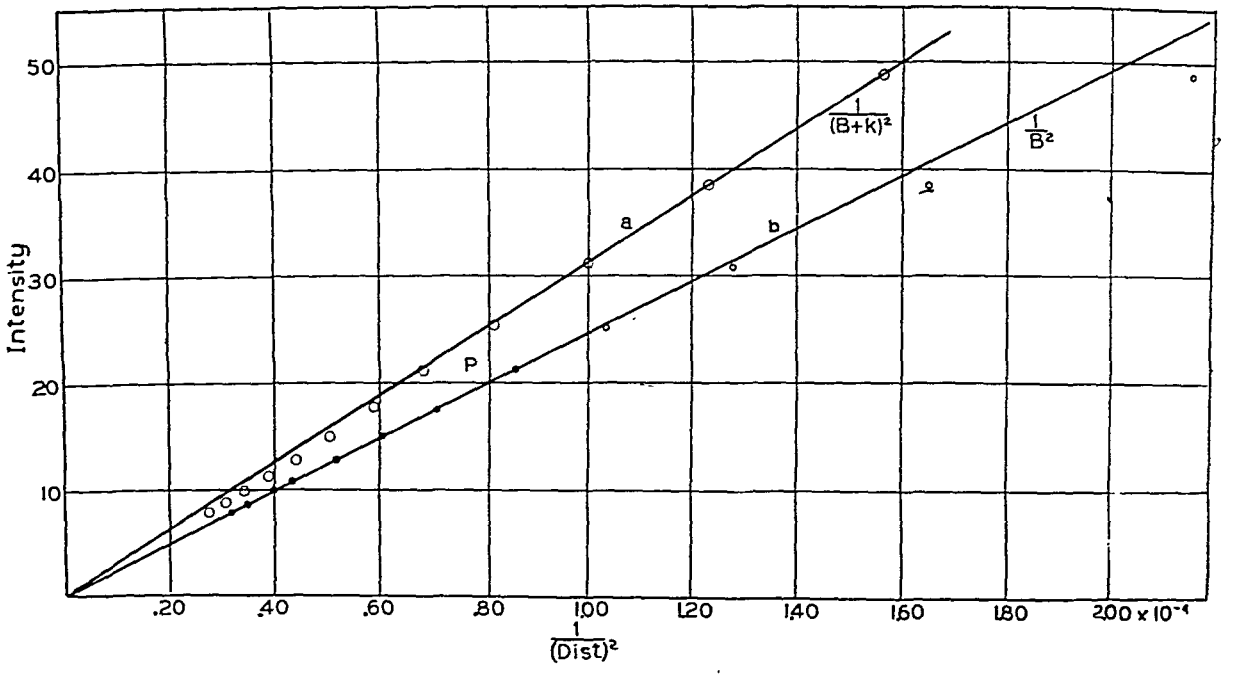


Fig. 2. Intensity of measured ionization as a function of 1/(distance)².

a point source (Equation (4b)), or an extended source within fixed limits (Equation (10)) the product of the area of the ionization chamber diaphragm by L determines the *effective air volume;* with the condition that in the first case the inverse square law is used with the source at the focus, while for the second it is used with the source considered at the first diaphragm M. The experimental justification for this is given in Section III.

Equation (11) should express actual conditions within experimental limits so long as $\cos^2 \beta_0$ differs from unity by less than the permissible experimental error. Having fixed the maximum permissible variation in flux density we may determine the range of magnitudes over which the equations above are valid. This, of course, depends upon the aperture of the system, so that for any given system the region over which an accurate determination of the r-unit is possible may be determined.

As indicated in Figure 1 (c), the focal spot must fill the aperture if the assumptions made are valid; that is, from Equation (7) we must have

$$f > \frac{ka+kb+Ba}{B} \qquad (12a)$$

If in a particular case

$$f < \frac{ka+kb+Ba}{B} \qquad (12b)$$

for a part of the range of B, then the inverse square law should be applied, using the distance from diaphragm N to the focus instead of to M, the diaphragm M serving simply to reduce the radiation coming from points other than the focus. If we have a sufficiently small focal spot (one which never fills the aperture) and a diaphragm system such that $\cos^2 \beta_0 \geqq 0.995$, we can determine the volume of ionized air as accurately as the experimental precision warrants by assuming a point focus. These conditions have not been realized by all observers.

III. EXPERIMENTAL STUDY OF DIAPHRAGM SYSTEM

1. Type of diaphragms used.—First, a study was made to determine if the form of the edge of the circular diaphragms used affected the measured magnitudes. One-quarter inch lead diaphragms having the same diameter (10 mm.) were prepared, all having different edges. The first group were tapered, ranging from 0° to 15°. The next group were beveled, leaving a half thickness of lead as an edge. In no case was a measurable difference produced in the ionization current. The diaphragms subsequently used were all of this beveled type.

2. Test of inverse square law.—According to Section II, 2, so long as the aperture of the diaphragm system is filled (Equation (12a)) by the extended focal area the distance B between diaphragms M and N should be used and the inverse square law applied thereto. When it is not filled, the distance $(B+k)$ from the focus should be used.

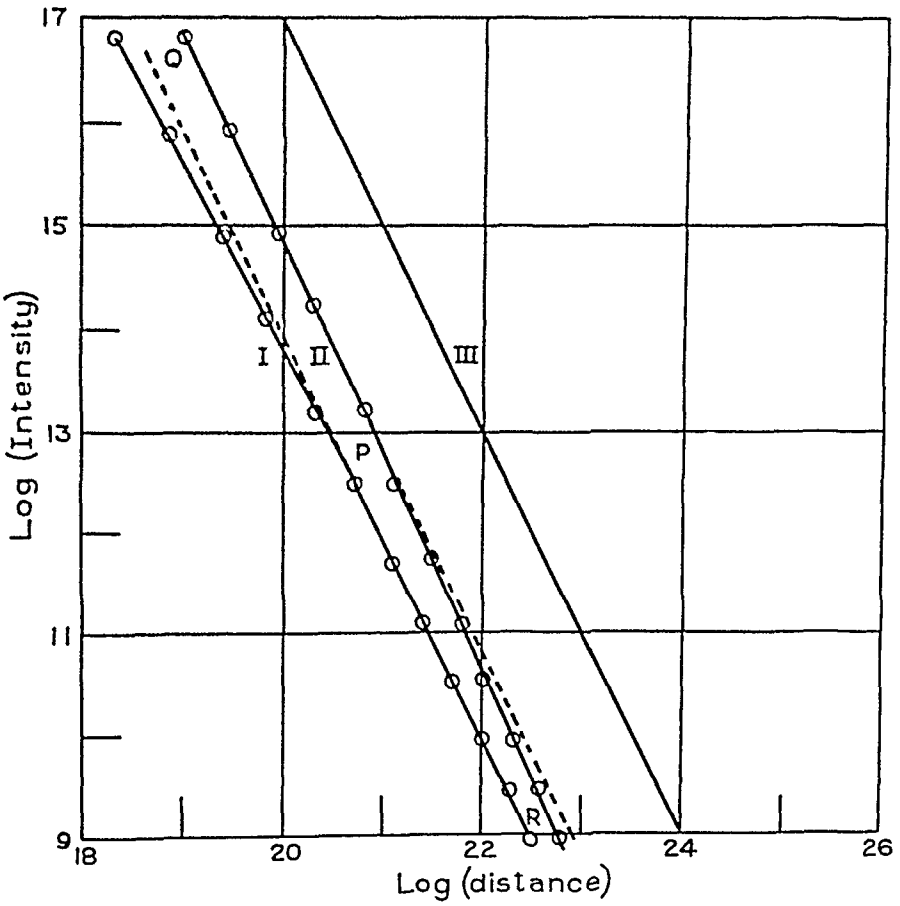


Fig. 3. Validity of inverse square law.

To test this the ionization chamber was mounted on a track of such length that the distance between focus and limiting diaphragm N could be varied from 40 to 200 cm.; the radius of the diaphragm M could be varied from 2 to 6 mm. and that of N from 2 to 10 millimeters. A null reading electrostatic system was used for measuring the ionization currents and a constant voltage generator for the X-ray tube.[15]

To align the system accurately, the ionization chamber track was leveled and approximately adjusted by sighting through the dia-

[15] See Footnote 6.

phragms at the target. A fine wire was then strung along the axis of the system and the track further adjusted until the wire remained in the center of the front and back chamber diaphragms for all positions of the

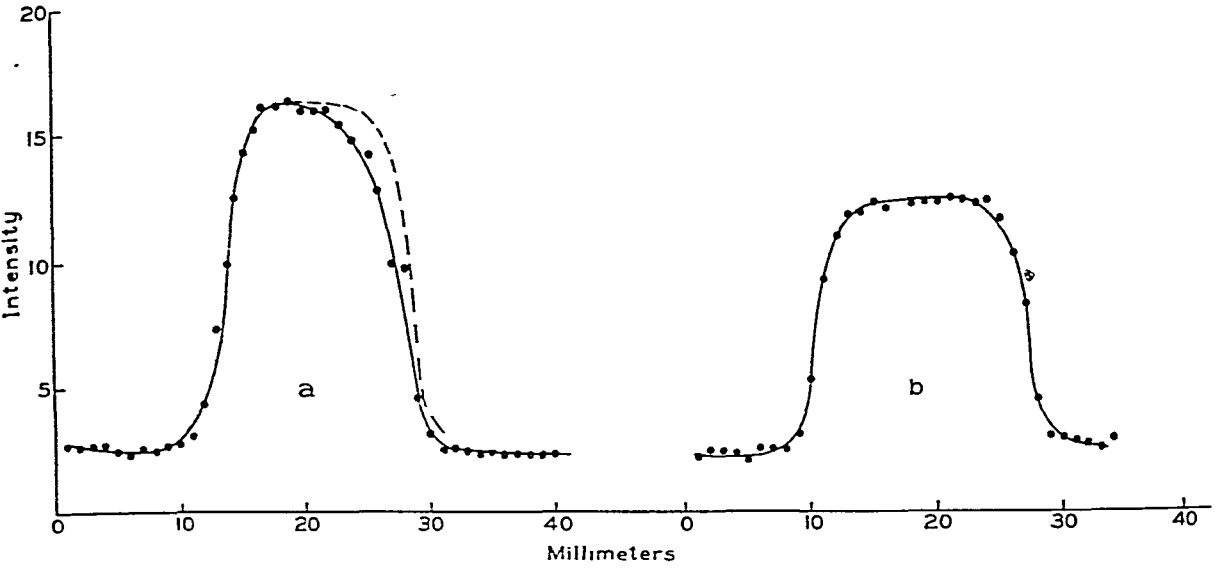


Fig. 4. Distribution of intensity across the standard X-ray beam. (The relative height of Curves *a* and *b* has no significance.) Curve *a*, for displaced diaphragms; Curve *b*, for properly aligned diaphragms.

chamber along the track. This was accomplished even more accurately by inserting in the diaphragms disks having very small holes in the center.

Curve *b* in Figure 2 gives (for $a=b=0.5$ cm., $k=12$ cm., and $f=$about 0.62 cm.) the observed X-ray intensity or ionization current i, plotted against the inverse square of the distance B between the tube focus and the ionization chamber diaphragm N. As should be expected, up to a certain value of $1/B^2$ corresponding to a distance $B=105$ cm., the intensity is found to be strictly proportional to $1/B^2$. According to Equation (7), a break in this proportionality should occur when

$$\frac{ka+kb+Ba}{B}=0.62$$

Thus in this case the calculated value of f is 0.62 as compared with the observed value 0.61, obtained when the break occurred at $B=105$ centimeters.

Likewise if i is plotted against $1/(B+k)^2$ a break occurs at the point corresponding to $B=110$ cm. (Curve *a*) except that in this case the portion of the curve corresponding to distances near the tube obeys the inverse square law.

The inverse square law may be expressed as

$$\log i=\log c-2\log H \qquad (13)$$

where c is a constant and H is the distance, either B or $(B+k)$ as the case may be. By plotting (Fig. 3) the data, the log of the intensity (proportional to log i) against that of the distances B or $(B+k)$, as the case may be, the applicability of Equation (13) is tested. For Curve *I*, H is taken as the distance B between diaphragms M and N; while in Curve *II*, H is taken as the distance $(B+k)$ between N and the focus. Curve *III* represents the slope (minus 2) which Curves *I* and *II* should have if the law expressed in Equation (13) is obeyed. It is to be seen that, of Curve *I*, the portion *PR* is parallel to *III*; while of Curve *II*, the por-

tion PQ is parallel to III. Hence the experimental results bear out the conclusions that for distances within a certain range near the tube the inverse square law should be applied with the distance $(B+k)$; while

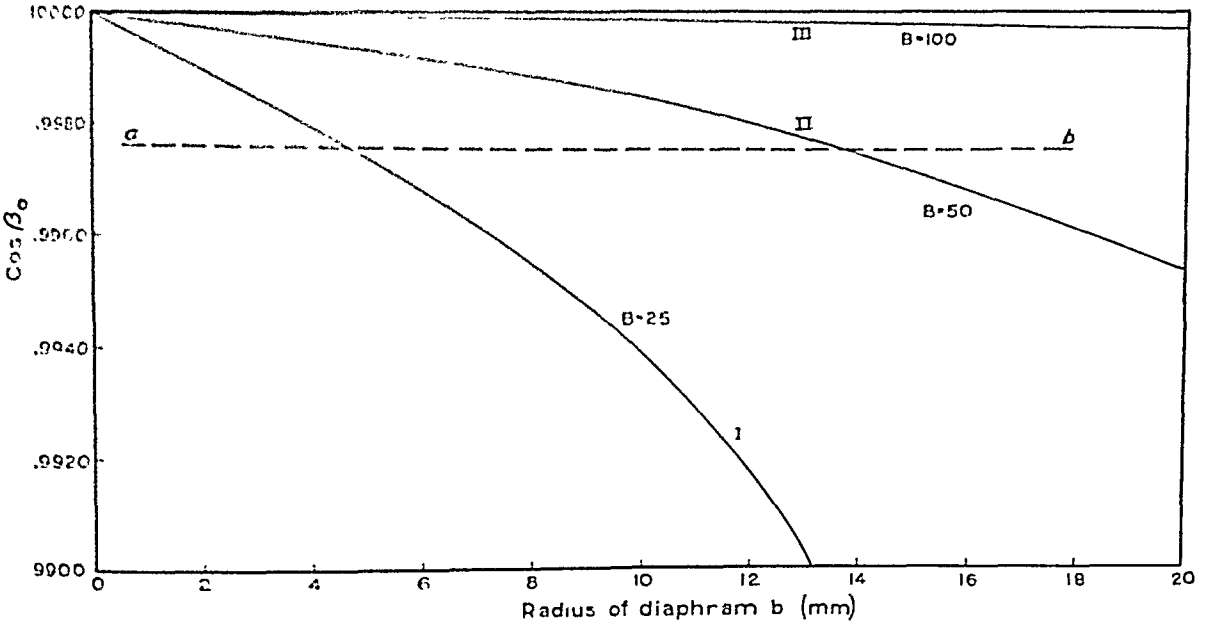


Fig. 5. See text, this page.

over the range farther from the tube, the distance B is used instead.

It is thus clear that the assumption of neither a point source nor an extended source is valid under all conditions; hence, special care must be taken in any experimental set-up to decide which may be used.

3. Uniformity of X-ray flux.—To check if the flux obeyed the conditions assumed for deriving the equations of Section II, the uniformity of the flux over the cross-section of the beam in the center of the ionization chamber was tested by exposing photographic plates in this plane, the exposure being varied over wide limits of time. With a proper alignment of the diaphragm system, the distribution over the central area should be uniform. That this proved true is shown in Figure 4 (*b*) where the photographic density, obtained by measuring the resulting photographic plate with a Marten's photometer, is plotted against position across the beam. With the X-ray tube and first diaphragm displaced laterally about 0.5 cm. from the central position, a photographic plate exposed inside the ionization chamber, gave the distribution shown in Figure 4 (*a*)—the dotted line giving the expected density for a perfectly symmetrical beam. As expected, the densities were greater on the side toward which the source was shifted. The irregularity with which the observed curve fluctuates about the smooth curve can well be ascribed to the inhomogeneity of the photographic emulsion.

4. Choice of operating conditions.—Two special cases may be given which illustrate how the geometrical analysis of the diaphragm system permits conditions to be chosen that yield an accurate determination of the ionization per unit volume. Letting β_0 be the maximum angle of divergence between the axis and the rays passing through the diaphragm system, then Curves I, II, and III (Fig. 5) give the values of cos β_0 plotted against the radial position in the ionization chamber for three cases where

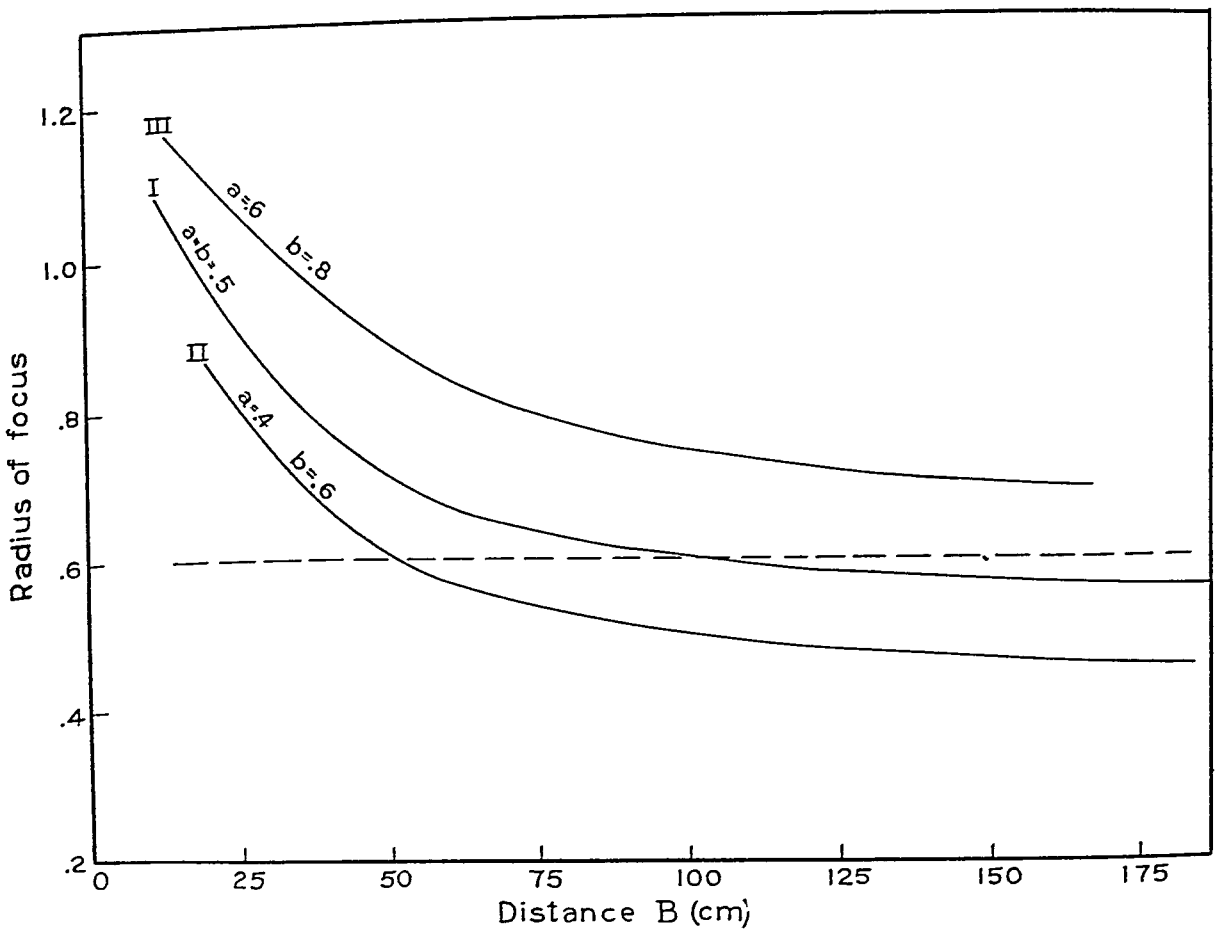


Fig. 6. See text, this page.

B=25, 50, and 100 cm., respectively, where a=0.4 centimeter. The values of cos β_0 are obtained from the relation

$$\frac{\beta_0}{2}=\tan^{-1}\frac{a+b}{B}$$

from Figure 1 (c).

If we stipulate that $\cos^2 \beta_0$=0.9950 introduces the maximum permissible error—which means an error of less than 0.25 per cent in r-units—it is seen that any physical conditions whereby cos β_0=0.9975 may be used. Thus the intersection of any curve in Figure 5 with the line ab=0.9975, gives at once the upper limit within which our approximations would be valid. In Curve I for B=25 cm. it is seen that b must not exceed about 0.5 cm.; in Curve II for B=50 cm., b must not exceed 1.4 cm.; while Curve III for B=100 cm. indicates that b may become extremely large before exceeding the given limit.

From Equation (7), giving the radius of the focal spot necessary to fill the aperture, we may plot curves which indicate the diaphragms and distances which may be used and yet fulfill the condition that $f>(ka+kb+aB)/B$. If, for instance, we have a focal spot of radius 0.6 cm., any set of conditions composing the portion of the curve (Fig. 6) below f=0.6 may be used. Thus in Case I, where the diaphragms M and N have a radius of 0.5 cm. each, the distance B must never be less than 100 centimeters. In Case II where a=0.4 and b=0.6 cm., B may be reduced to 50 cm., while for a=0.6 and b=0.8 cm. no value of B whatever will suffice.

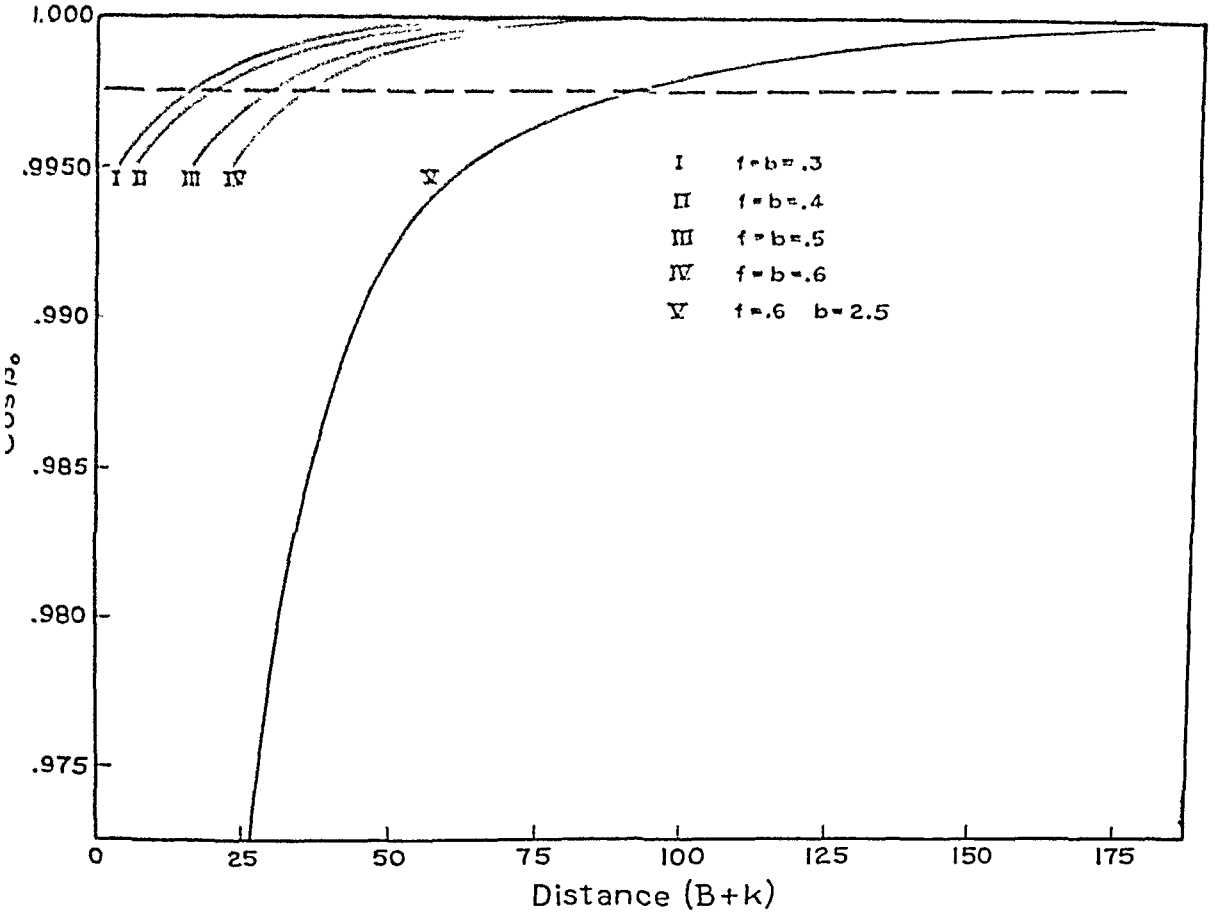


Fig. 7. See text, this page.

In the standardization equipments used by Behnken, Duane, and Glasser, each has a diaphragm corresponding to M. However, it is probable that their focal spots did not completely fill the aperture of the system, so that for the purpose of indicating the allowable deviation in each, we may consider the aperture as determined by the radii of the focal spot and diaphragm N and the distance $(B+k)$. We may then compute $\cos \beta_0$ as a function of $(B+k)$ for different radii of the diaphragm N and so determine the range over which the allowable error in measuring the air volume is not exceeded. A set of these relations are plotted in Figure 7. All conditions falling on the curves above the line at $\cos \beta_0 = 0.9975$ may then be used without introducing more than the stipulated error.

Consider now three of the well-known X-ray standardization equipments:

I. Behnken[16] (Physikalische Technischen-Reichsanstalt).—$(B+k)=105$ cm.; the radius of the focal spot f and diaphragm N are about the same and equal to 0.35 cm., making $\cos \beta_0$ fall between Curves I and II in Figure 7, thus indicating a very small error which may be neglected.

II. Glasser[17] (Cleveland Clinic).—$(B+k)=45$ cm. and $f=b=0.4$ centimeter. The point fulfilling these conditions falls on Curve II, well above $\cos \beta_0=0.9975$, also indicating a very small error.

In the two cases above, the focal spot may be slightly greater than indicated, but,

[16]Behnken, Hermann: Strahlentherapie, 1927, XXVI, 79.
[17]See Footnote 4.



Fig. 8 Pinhole photographs to indicate the magnitude of off-focus radiation.

even so, the maximum error will be less than 0.5 per cent.

III. Duane[18] (Harvard University).—This system has for N a rectangular diaphragm 0.5 by 5.0 cm., and $(B+k)$ is approximately 60 centimeters. The energy distribution across the beam in the 0.5 cm. direction will be uniform within the necessary limits. Along 5.0 cm. direction, however, the variation in cos β_0 with $(B+k)$ is shown in Curve V, whence it is seen that for $(B+k)=60$, the maximum error in $\cos^2 \beta_0$ is about 1.6 per cent, and, therefore, can not be neglected. In order to reduce this error to within the prescribed limits, we must make $(B+k)=90$ centimeters.

IV. INFLUENCE OF "OFF-FOCUS" RADIATION

Off-focus radiation may be defined as that *radiation from an X-ray tube which originates from points on the target face other than the sharply defined focal spot.* If a diaphragm M be used which is sufficiently small, "off-focus radiation" does not enter. In this radiation lies another possible source of error in standardization measurements, and on account of the difficulty in accurately measuring its magnitude most observers have avoided a quantitative study of the question. Glasser[19] has indicated the importance of screening the ionization chamber diaphragm (N) from radiation coming from the stem and the body of the target other than the face. Likewise, Behnken,[20] Failla,[21] Duane[22] and most others have taken similar precautions, although in every case the method was entirely arbitrary.

A pinhole photograph of the target taken through the diaphragm system will indicate any source of off-focus radiation. Especial

[18] See Footnote 5.
[19] See Footnote 4.
[20] See Footnote 16
[21] See Footnote 9.
[22] See Footnote 5

care, however, must be used in making such photographs, since an under-exposed plate may apparently indicate a good focal spot and little off-focus radiation; an over-exposure indicates general radiation from the whole face; whereas an exposure commensurate with the limiting error would give some indication of the actual off-focus radiation in proper proportion to the focal spot radiation. These three cases are shown, respectively, in Figures 8 (*a*), (*b*), and (*c*). While the amount of off-focus radiation will usually be but a small percentage of the focal spot radiation, it may at times be of too great a magnitude to be neglected.

To measure the off-focus radiation, the diaphragm N was fixed and the ionization chamber placed at a fixed distance from the tube such that the aperture of the diaphragm system did not introduce more than 0.5 per cent maximum deviation in the flux density across a plane within the chamber. Ionization current readings were made as the diaphragm M was varied from a diameter of 0.4 to 1.2 centimeter. The curve in Figure 9 shows the intensity ($\propto$ to ionization current) plotted against a^2 ($\propto$ to area of M)

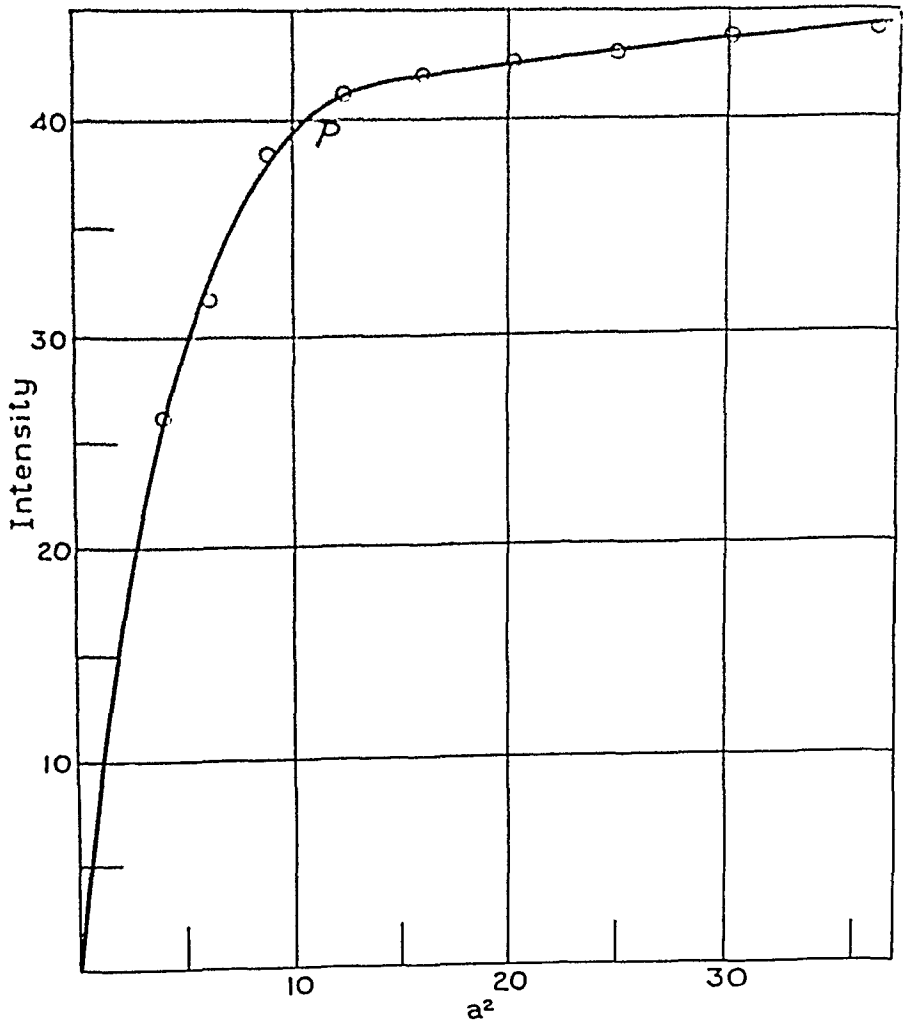


Fig. 9. Measure of the proportion of off-focus radiation to focal spot radiation for a particular tube.

for a 200 K.V. Coolidge tube having a focus of radius about 0.4 centimeter. It is seen that the intensity increases very rapidly up to a point P which corresponds to the condition where the sharply defined focus just fills the aperture, while beyond this point the ionization increases very slowly and somewhat irregularly. Nevertheless, a continual increase is evident and no saturation value of the X-ray flux was indicated over the range studied. It is thus seen that for this particular tube and diaphragm system, the magnitude of this off-focus radiation can not be neglected.

It is probable that if two observers were to use, respectively, diaphragms M of 0.9 and 1.5 cm. diameter for such a tube some correction would have to be applied to make their measured r-units agree. Similar curves obtained for two other tubes showed differences in their respective off-focus radiation.

Referring to Curve II in Figure 5, showing the validity of the inverse square law, we have seen that the upper portion PQ gave the nearest approach to the proper slope of —2. However, there is a very slight but definite divergence which may probably be attributed to the off-focus radiation, since the quantity of this radiation entering the ionization chamber varies with the distance B. Over the lower part PR of Curve I the slope is exactly —2, indicating good agreement with the inverse square law. (Equation (13).)

Behnken and Glasser have diaphragms M of 15 and 12.5 mm. diameter, respectively, placed in each case about 15 cm. from the target. Their X-ray tubes have focal spots of different size. It is therefore evident

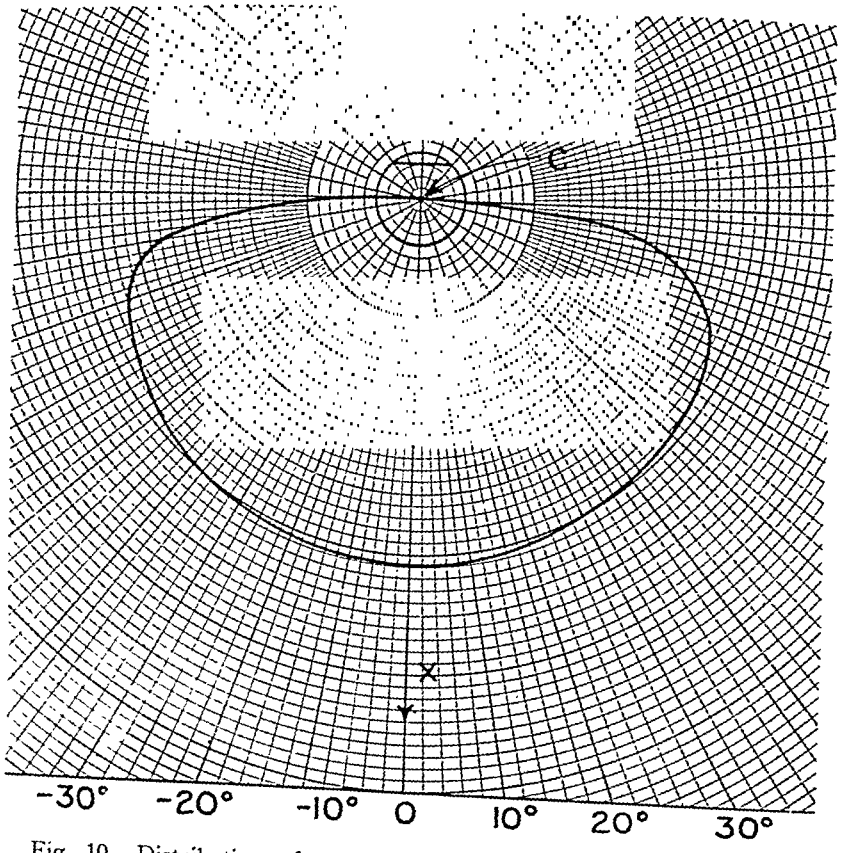


Fig. 10. Distribution of energy about 200 K.V. deep therapy X-ray tube target in a plane normal to the tube axis.

that both may have quite a different ratio of on-focus to off-focus energy, and thus introduce discrepancies between their r-units. Again, Failla has no diaphragm close to his X-ray tube, but restricts his scattered radiation by a diaphragm some 30 cm. away from the focus. He has given a detailed discussion[23] of the changes in ionization due to varying the size and positions of his diaphragms. These differences in experimental technic require that proper allowance be made for off-focus radiation or else it must be completely shielded from entering the ionization chamber, which may be accomplished by using a diaphragm system wherein the focus always fills the aperture.

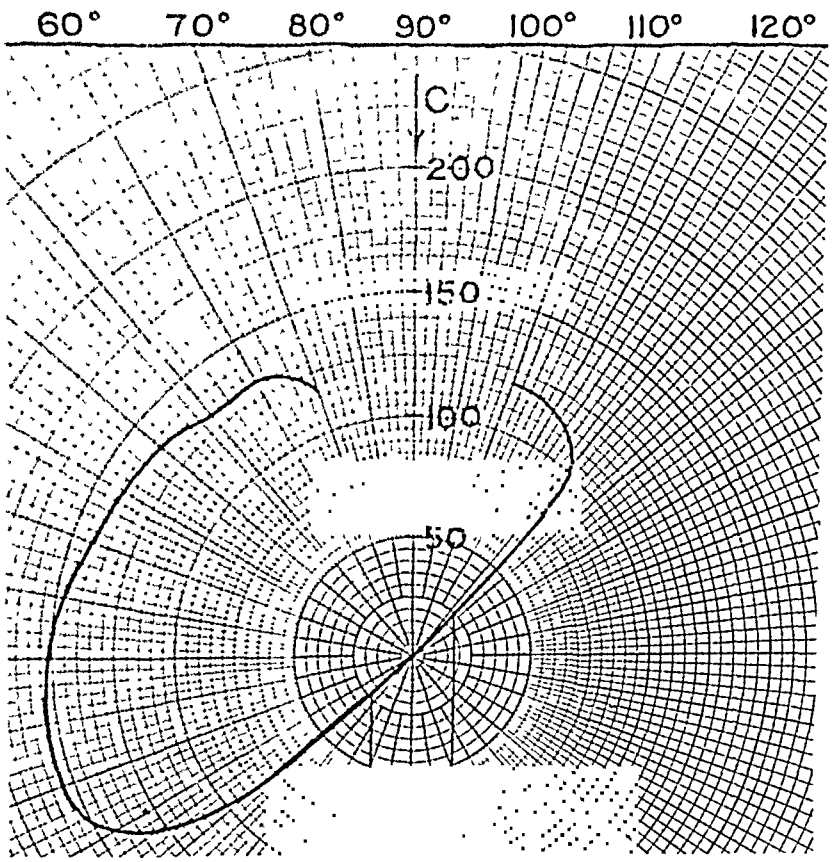


Fig. 11. Distribution of energy about target in a plane through the tube axis and the normal to the target face.

V. ERRORS DUE TO ENERGY DISTRIBUTION ABOUT THE TARGET

In three cases noted above (Failla's, Behnken's, and Glasser's) the radiation is taken off the target face at an angle of 45°, and at 90° to the cathode stream. Duane's diaphragm system is similar to that of Behnken and Glasser, except in being rectangular. However, it is dissimilar in that the radiation is taken off the target at a small angle of some 10° to 15°, and, consequently, it is important to determine whether there is any possible error due to the uneven distribution of energy with angular direction about the focus.

The energy distribution about a massive target has been studied by Kaye,[24] Coolidge,[25] and others and is shown in Figure 10 for a 45° angle between cathode stream and normal to the target, the data being

[23] See Footnote 9.

[24] Kaye, G. W. C.: Proc. Royal Soc., London, 1910, LXXXIII, 189. Kaye found that as the angle between normal and cathode stream changed the distribution about the normal did not vary much.

[25] Coolidge, W. D., and Kearsley, W. K.: Am. Jour. Roentgenol, 1922, IX, 77.

taken from the paper by Coolidge and Kearsley and replotted on polar instead of rectangular co-ordinates. Figure 11 likewise shows the energy distribution about the focus in a plane perpendicular to the by Duane, the tube tilted to an angle of about 35° and rotated about +70° to 75° from its normal position, and the cross-section of the beam photographed behind the second diaphragm. The resulting plate

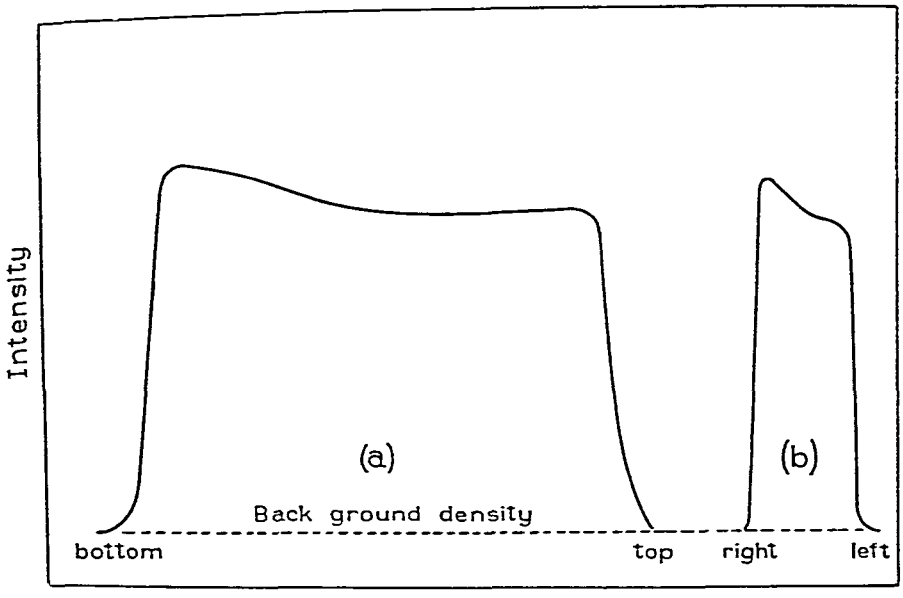


Fig. 12. Distribution of energy across a rectangular beam taken from the target at a glancing angle.

cathode stream. It is seen from the curves in Figure 10 that the distribution is nearly uniform in the direction used by Behnken, Glasser, and the Bureau of Standards. This is the direction in which radiation is usually taken in practice. At glancing angles to the target, however, the change in distribution is very rapid, so that the flux density across a plane x, as considered in Section II, should decrease appreciably in passing from one side of the beam to the other.

In Duane's case, where long rectangular slits are used, we should expect, therefore, an appreciable change in the flux density across the beam. Of course, if the diaphragms are sufficiently small such a change would be very small and could be neglected. A photographic determination of this effect was easily obtained. A rectangular diaphragm system was set up and carefully aligned so as to correspond to that used densities are indicated in Figure 12, curve a being taken lengthwise of the rectangular diaphragm, and curve b crosswise. As should be expected, the lower part of the field is more intense than the upper and likewise the right side more intense than the left. These inequalities were obtained likewise in the opposite direction when the tube was rotated through —70° to 75°.

The variation in flux density here considered is entirely independent of that due to the cosine law; it is, however, possible that the two may be present at the same time. In an accurate comparison of the r-unit between two laboratories care must be taken that such errors are small enough to be neglected. An ideal standardization equipment would have the X-ray tube so constructed that the radiation is taken normally from the target.

In the author's first paper,[26] a careful study was made of the several methods used in measuring air ionization with particular reference to the accuracy of each method. As a consequence of the differences found, an improved method was tested and found to be satisfactory. In the present paper, the methods for obtaining the effective volume of air ionized have been analyzed, the results being summarized below. The next logical problem is that of analyzing the methods used in the comparison of the r-unit between the different laboratories having a standard ionization chamber. This problem is being undertaken at present at the Bureau of Standards.

SUMMARY

1. Previous investigators have assumed the X-ray tube focus to be a point source. Experiments described in the present article indicate that the assumption of a uniform and extended focus yields instead a more reliable determination of the r-unit when the distance between X-ray tube and standard ionization chamber is such that the focal spot area fills the diaphragm aperture. In this case the inverse square law is valid when applied to the distance between the X-ray tube diaphragm and the entrant diaphragm of the ionization chamber.

When the X-ray tube diaphragm is not filled the inverse square law should be used with the distance between the target and the entrant diaphragm of the ionization chamber. Off-focus radiation may impair, however, the accuracy of the results in this case.

2. The use of a limiting diaphragm close to the X-ray tube may introduce an error in the measurement of the ionization in the effective volume, this being due to the off-focus radiation entering the chamber. Such error may introduce discrepancies between the r-unit as established in various laboratories.

3. By having incorrect alignment of the diaphragm system serious error may be introduced in measuring the effective volume.

4. Due to non-uniform energy distribution about the target, the use of narrow rectangular diaphragms is inadvisable except under carefully determined conditions.

5. Using diaphragms of the same size, but having edges beveled at different angles, introduces no measurable difference in the ionization.

6. The discrepancy in measurements of the air volume under the conditions used by other observers is shown to lie within expected error.

Discussion of these problems with the various investigators cited has been very helpful. Recognition is due G. Singer and C. G. Malmberg, of the Bureau, for their assistance in the experimental work.

[26] See Footnote 6.

X-RAY DIFFRACTION IN LIQUIDS

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TWO questions are considered in this paper: the correct interpretation of the inner (secondary) ring familiar in many liquid diffraction patterns, and a brief survey and evaluation of the possibilities of the photographic method of recording X-ray diffraction patterns of liquids.

When X-rays are transmitted through the alcohols or fatty acids or certain other long-chain compounds two diffraction maxima are produced. According to Stewart,[1] the outer ring, corresponding to the smaller spacing, is a measure of the cross-section of the molecule, while the inner one is associated with the length of the molecule. On this interpretation is based his theory of cybotaxis. Recently Thibaud and Trillat have stated[2] that only the outer ring is dependent on the size of the molecule while the inner ring is in every case due to general radiation and bears no relation to the length of the molecule. Obviously the question is of vital importance and should be settled before further studies of X-ray diffraction in liquids are undertaken.

The contentions of Thibaud and Trillat are, briefly, as follows: The inner (secondary) ring is due to a filtration of the general radiation by the liquid itself. If the specimen is less than 2.0 mm. thick, no inner ring is produced, and as the thickness of the specimen increases the intensity of the inner ring increases in comparison with that of the outer ring, since the Kα radiation is absorbed to a greater extent than is the general radiation. The diameter of the inner ring varies with the tube voltage, the ring diffusing toward the center as the voltage is increased. Other things being equal, the position of the inner ring is affected by the particular liquid used, since its size is a function of the coefficient of absorption of the liquid. Remarkable agreement is shown between the experimental values for the inner ring and the values calculated from absorption data. Thibaud and Trillat say little about the origin of this inner ring aside from the fact that it is due to general radiation. It must be diffraction produced by an identity period of some sort, however, and if it is not related to the length of the molecules then it must be related to the interplanar spacing corresponding to the cross-section. A similar ring is produced on pinhole diffraction patterns of steel. The inner edge of the ring is determined by the voltage on the tube and the outer edge by the absorption limit for silver. The diffraction of the general radiation is produced by the 110 planes of iron, the same which produce the most intense diffraction ring with K α radiation.[3] It should be noted that Stewart considers in his first paper the possible effect of general radiation, and this point is discussed below.

It is a comparatively simple matter to choose qualitatively but conclusively between these two interpretations. If two isomers are chosen, each having the same number of atoms and therefore the same absorption coefficients, and X-ray diffraction patterns are obtained for both, using identical tube voltages and thickness of specimens, then according to Stewart the size of the inner ring will depend on the length of the molecule, while according to Thibaud and Trillat it will depend on the cross-section of the molecule. Fortunately in changing from a normal to a secondary or tertiary

[1] See several papers by Stewart and co-workers in *Physical Review* for 1927, 1928, 1929, and 1930.

[2] Thibaud and Trillat: Compt. rend., 1929, pp. 751, 907.

[3] Clark: Metals and Alloys, 1929.

TABLE I

READINGS TO ESTABLISH ACCURACY OF VISUAL MEASUREMENT OF DIFFRACTION MAXIMA

	Diameter of Diffraction Rings (cm.)			
	n-amyl Alcohol		Secondary amyl Alcohol	
Observer	Outer	Inner	Outer	Inner
1	2.30	1.40	2.32	1.16
2	2.41	1.38	2.33	1.09
3	2.40	1.38	2.32	1.08
4	2.41	1.43	2.30	1.10
5	2.40	1.38	2.34	1.10
6	2.40	1.38	2.35	1.10

TABLE II

THE DETERMINATION OF THE PROPER SPECIMEN-TO-FILM DISTANCE

Liquid	Cell Thickness	Diam. of Ring	Distance Specimen to Film	d (calc.)
n-butyl alcohol	1 mm.	2.25 cm.	7.15 cm.	4.55 Å.
n-butyl alcohol	8 mm.	2.35 cm.	7.10 cm. (to near side of cell)	4.34 Å.
			7.5 cm. (to center of cell)	4.57 Å.
			7.9 cm. (to far side of cell)	4.80 Å.
secondary amyl alcohol	2 mm.	2.25 cm.	7.20 cm.	4.69 Å.
secondary amyl alcohol	8 mm.	2.32 cm.	7.1 cm. (to near side of cell)	4.41 Å.
			7.5 cm. (to center of cell)	4.65 Å.
			7.9 cm. (to far side of cell)	4.89 Å.

alcohol the cross-section increases and the length decreases, hence the diameter of the inner ring will increase if the first theory is correct and should decrease according to the second theory.

EXPERIMENTAL

Preliminary experiments were undertaken to establish the most favorable conditions for obtaining clear, sharp diffraction patterns. Molybdenum radiation was found to be superior to copper radiation. Although the rings produced have a smaller diameter, they are sharper and offer a greater contrast to the background and may be measured with less percentage error, either with the eye or with the microphotometer, than can those produced by copper radiation. The liquids were held in a brass cell with retaining walls of thin mica. The mica produces a faint Laue pattern which is not to be confused with the measurement of the more diffuse liquid rings. The thicker the specimen the shorter the time required to obtain a satisfactory pattern, other things being equal. At 39 K.V. tube voltage an 8 mm. specimen requires six hours' exposure, while a 2 mm. specimen requires over 24 hours, using the same pinhole system. It is interesting to note that the thickness of the specimen apparently does not make the rings noticeably more diffuse. One might conclude from this that it is only molecules oriented at the interface which produce diffraction and the effective diffracting thickness remains constant as the thickness of the specimen is increased beyond a cer-

tain value. The fact that increased thickness decreases the time of exposure required refutes this conclusion, however, as do the data in Table II, indicating that the measurement of the plate-to-specimen distance should be made to the center of the specimen. The effect of thickness of specimen on the nature of the diffraction should be subjected to further quantitative study. A thickness of 8 mm. was chosen for most of the experiments since that is the thickness used by Stewart in all his work and by Thibaud and Trillat in much of theirs. The radiation was filtered through one thickness of zirconia.

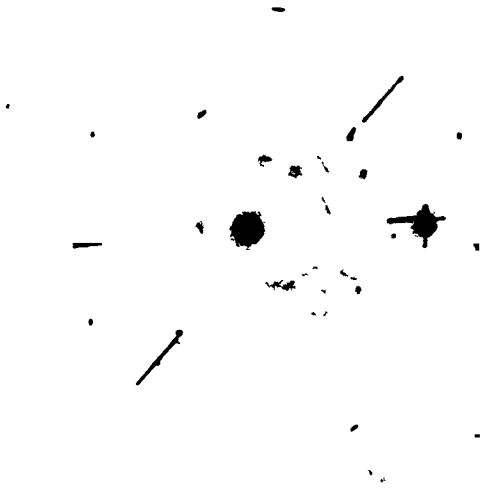


Fig. 1. n-amyl alcohol (35 K V.).

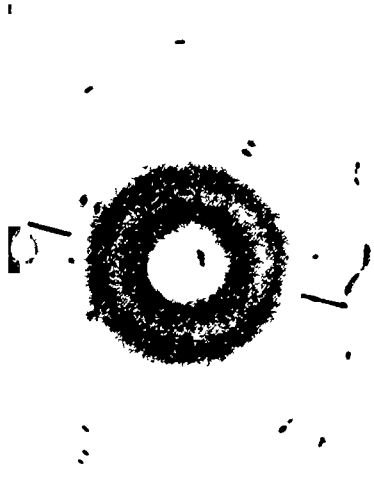


Fig 2 ter-amyl alcohol (35 K.V).

There are two main sources of error in the determination of the interplanar spacings. The measurement of the diameter of the ring is doubtless the main source, its magnitude depending on the diffuseness of the pattern and on the density of the negative. Some liquids produce much sharper diffraction rings than others. To establish the degree of accuracy attainable by measuring the diameter directly from the film, using dividers, two films were selected, one fairly dense and one fairly thin, and submitted to trained. independent observers. Their results are recorded in Table I. It is evident that the maximum error for the outer ring may be placed at 0.05 cm., or about 2 per cent, while the maximum error for the inner ring, which seems to be more difficult to measure, is 0.08 cm., or 7.3 per cent. The results indicate that it is reasonable to expect a degree of accuracy better than these maximum values from a trained observer. All these measurements were made on the most diffuse patterns (see Fig. 1). The percentage error may be halved on the patterns which are sharp (see Fig. 2). It is difficult to increase the accuracy greatly for this type of pattern by using a microphotometer, due to the general fogging of the negative which cuts down the contrast. The zirconia filter decreases this fogging considerably and further efforts are being made to eliminate it. It is entirely possible to obtain a microphotometer which, when used on films of ideal intensity, will reduce still further the error in direct measurement. The distance from specimen to film may be accurately measured. With a thick specimen the question arises as to the point in the specimen from which the distance should be meas-

TABLE III

Liquid	Thickness	Tube Volt.	Diam. of Rings Inner cm.	Diam. of Rings Outer cm.	d (calculated) Inner Å.	d (calculated) Outer Å.	Published Data* Inner Å.	Published Data* Outer Å.	Wave Length Inner Ring Å.
n-butyl alcohol	1 mm.	35 K.V.		2.25		4.55	11.1	4.4	
n-butyl alcohol	8 mm.	35 K.V.	1.28	2.35	8.36	4.57	11.1	4.4	.39
Benzene	8 mm.	35 K.V.	1.28	2.25	8.36	4.77		4.7	.405
Tertiary amyl alc.	8 mm.	35 K.V.	1.20	2.18	8.89	4.92	8.5	5.05	.392
n-amyl alcohol	8 mm.	35 K.V.	1.38	2.41	7.93	4.46	12.6	4.4	.407
iso-amyl alcohol	8 mm.	33 K.V.	two rings						
iso-amyl alcohol	8 mm.	31 K.V.	three rings						
iso-amyl alcohol	8 mm.	29 K.V.	three rings						
Tertiary amyl alc.	8 mm.	27 K.V.	1.22	2.18	8.75	4.92	8.5	5.05	
Secondary amyl alc.	8 mm.	27 K.V.	1.10	2.32	9.71	4.65	11.3	4.80	

Maximum error: In outer ring (2%) = 0.1 Å., inner ring (7%) = .65 Å.
Probable error: 0.06 Å .25 Å

*Stewart and Skinner: Phys. Rev., 1928, XXXI, 1.

ured. This was established by obtaining the diffraction pattern for the same substance in a thin cell (in which case there is no question about the distance), determining the corresponding interplanar spacing and then comparing this value with the interplanar spacings calculated by assuming different film-to-specimen distances in the thick cell. The data for two independent determinations are set forth in Table II. It is evident that the distance should be measured to the center of the cell, which is the result most naturally to be expected. With this procedure the error in measurement is negligible.

The main advantages of the pinhole photographic method are the elimination of expensive apparatus and the possibility of obtaining direct, permanent, visible records. The accuracy attainable without the microphotometer justifies its use in many problems. By using a microphotometer the first advantage is lost but the accuracy may be doubled. With careful control of conditions it is probable that the photographic method will prove useful for all but the most precise work.

Using the procedure described above, X-ray diffraction patterns were obtained for the liquids listed in Table III. With the help of Stewart's data liquids were chosen which would give the most marked diffraction maxima in the positions most useful in settling the point at issue.

DISCUSSION OF RESULTS

The first three listed in the table are in the nature of preliminary experiments. No inner ring is obtained for the thin (1.0 mm.) specimen, even with 54 hours' exposure, under the same conditions which produce such a ring in six hours with the 8.0 mm. specimen. This is in accordance with the observations of Thibaud and Trillat, but we do not feel that it is significant inasmuch as the diffracted radiation is so weak under these conditions anyway.

With normal butyl alcohol it is significant that the inner ring corresponds to a spacing quite different from the published value for the length of the molecule. Stewart and Morrow have demonstrated the appearance of a diffraction maximum at certain tube voltages due to general radiation and the position of this inner maximum for

n-butyl alcohol agrees reasonably well with that found by them.[4] Assuming that the inner ring is the result of the diffraction of the general radiation by the same interplanar spacing which diffracts the K α

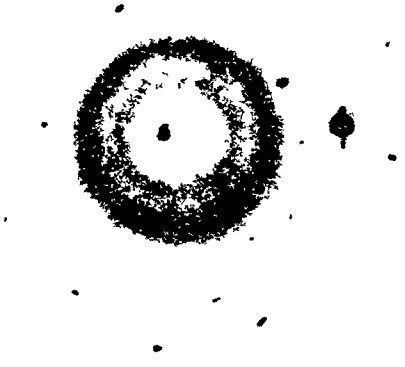


Fig. 3. Benzene (35 K.V.).

radiation to produce the outer ring (*i.e.*, the value corresponding to the cross-section of the molecule), we have calculated in the last column of Table III the wave length which would be so diffracted. This value (approximately 0.4 Å.) agrees reasonably well with the maximum effective wave length of general radiation at 35 K.V. as recorded by Siegbahn[5], if we allow for the fact that the peak would be shifted to a somewhat lower wave length by filtration by the zirconia and the liquid.

Stewart records only one diffraction maximum for benzene,[6] whereas at 35 K.V. we find two. Here again the inner ring is clearly due to general radiation (see Fig. 3).

The problem has been more systematically approached with the series of amyl alcohols listed. At 35 K.V. the inner ring is due to general radiation. As the voltage is decreased, the general radiation maximum becomes less marked. At 31 K.V. three rings were clearly indicated, reproducing the results obtained by Stewart when the exciting voltage was reduced in a similar manner. At the higher voltage the general radiation probably becomes intense enough to obscure the third, innermost maximum. At 27 K.V. the data indicate that the ring due to general radiation is absent and the inner ring is now the result of the diffraction of K α radiation by a spacing corresponding to the length of the chain. It must be admitted that the quantitative agreement with the published values is not all that could be desired. At present we cannot account for the discrepancy. It is beyond the range of experimental error in some cases and so far as we know the specimens are pure. Qualitatively, however, the results are conclusive. At 35 K.V., in going from tertiary to n-amyl alcohol the diameter of the inner ring increases, therefore the spacing producing the diffraction must be the cross-section of the molecule—which decreases—and not the length. At 27 K.V., in going from tertiary to secondary amyl alcohol the diameter of the inner ring decreases, hence the spacing producing the diffraction must be that of the length of the molecule—which increases. The relative intensities of the two rings as brought out by the microphotometric curves is also convincing. For the alcohols at 35 K.V. the inner ring is much more intense than the outer, while at 27 K.V. the reverse is true, the two rings bearing about the same relative intensity indicated by Stewart's ionization curves.

As we interpret the statements of Thibaud and Trillat, the inner ring is due to general radiation at all voltages. They give data for copper radiation varying from 15 K.V. to 40 K.V. They have not published similar data for molybdenum radiation but state that similar results are obtained. It is quite evident from the data herein pres-

4Stewart and Morrow: Physical Rev., September, 1927, XXX, 232.

5Spectroscopy of X-rays, Oxford Univ. Press, 1925, p. 208.

6Physical Rev., June, 1929, XXXIII, 889

ented that with a low enough voltage the inner ring is characteristic of the length of the molecule. These results are thoroughly in accordance with those of Stewart. Unfortunately, however, there was no possibility of applying Stewart's information on this point since he defined the proper voltage to use in terms of the primary voltage on his transformer rather than as the tube voltage. It has been demonstrated that the tube voltage must be considerably lower than that ordinarily used with molybdenum radiation in order to obtain characteristic liquid patterns.

SUMMARY

1. A preliminary survey of the possibilities and limitations of the photographic method of recording X-ray diffraction patterns of liquids has been made. It has been pointed out that only under very carefully controlled conditions are quantitative results obtained by this method reliable.

2. At a tube voltage of 33 K.V. or more the inner ring of the liquid diffraction pattern is produced by the diffraction and filtration of general radiation, and bears no relation to the length of the liquid molecule.

3. With a tube voltage of 27 K.V.—much less than the voltage usually used—the inner ring obtained is characteristic of the liquid under examination. It is, therefore, necessary to use this lower voltage in obtaining diffraction patterns for liquids.

ROENTGEN-RAY FINDINGS IN ERYTHROBLASTIC ANEMIA[1]

By F. B. MANDEVILLE, M.D., Instructor in Radiology, Yale University, New Haven, Connecticut

THE CLINICAL ENTITY

ERYTHROBLASTIC anemia (3) is a hemolytic anemia occurring in infancy and early childhood, its most striking hematologic characteristic being the presence of an extremely large number of erythroblasts in the circulating blood; at times, the erythroblasts outnumber the leukocytes. The etiology is obscure. The Italian medical literature more fully treats this phase of the condition, which will not be discussed in this paper. The disease is apparently confined to a fairly definite clinical group. Only one subject (18) suffering with this condition is known to have reached adult life. A familial tendency has been observed, although this has not been the rule, and it has been noted wholly in children of Mediterranean ancestry, more especially Italians and Greeks. The patients present a peculiar appearance resembling the Mongolian race, and have a muddy yellowish discoloration of the skin. The cranium demonstrates thickening and the malar eminences are prominent.

The disease begins in early infancy with a moderate anemia. There is a pronounced early enlargement of the spleen, the increase in size being progressive. Leukocytosis is of varying degree, although as a general rule it is only moderate. There is a normal or slightly decreased fragility to salt solutions, although a slight increase has been noted in occasional instances. Reticulated cells are markedly increased in number; the red blood cells are diminished and usually range from 1,600,000 to 3,500,000 per cubic millimeter. The color index is low. The urine is dark colored and urobilin is present. Removal of the spleen causes an enormous increase in the erythroblasts, lasting for years. There has been little definite improvement following the operation.

All of the cases noted in the literature which were examined by the roentgen rays demonstrated changes in some of the bones of the body, and all the investigators agree, in general, as to the appearances noted. In addition, roentgenograms of the bones in four cases, clinically diagnosed erythroblastic anemia, have been studied by us. Every case demonstrated some bone changes, the bone involvement varying somewhat in degree and distribution.

CLASSIFICATION

Further work on the classification of the anemias of infancy and childhood, associated with splenic enlargement, seems to be warranted, as no scheme satisfactory to clinicians, pathologists, and radiologists has been devised. The terms "primary anemia" and "secondary anemia," as used in the past, are not considered fully satisfactory by many investigators. The division of the anemias into the congenital and acquired types is sometimes confusing, as it is often difficult to establish the time of onset and the etiologic factors concerned in certain cases. For practical purposes, the terms "hemolytic" and "non-hemolytic" are often far more satisfactory. Karshner (22) has presented a classification which may be of value until further work on the etiology of the various anemias suggests a more logical one. Anemias are divided into three groups—

(1) Due to blood loss.
(2) Due to defective blood formation.
(3) Associated with increased blood destruction.

In most of the anemias, according to pathologists (22), there are changes in the bone marrow. Unfortunately, all the

[1]Cases studied by courtesy of the Departments of Pediatrics and Radiology, Yale University, School of Medicine.



Fig. 1. Case 1, aged 15 years. Lateral view of the skull showing the thin inner and outer tables, enormous widening of diploë, with its characteristic porous appearance. The diploë adjacent to the outer table presents striations perpendicular to the tables of the skull.



Fig. 2. Case 2, aged 11 years. Skull similar to Case 1. There is a general prominence of the facial bones.

changes are not demonstrable on the roentgenogram, so that the radiologist fails to differentiate the three large groups of anemia founded on principles of pathologic physiology. And for this reason the investigator might ask, "Why has an attempt been made to study the roentgen-ray appearance of the bones in such a comparatively rare disease as erythroblastic anemia?" The reply is that the changes noted on roentgen-ray examination are not common in the anemias, but, when they do occur, they are often striking, and of material aid in the diagnosis.

As Whitcher (40) states in a recent article, the findings in erythroblastic anemia seem to justify its consideration as a definite clinical entity. For some time to come, however, cases will probably be classed un-



Fig. 3. Case 2, aged 11 years. Postero-anterior view.

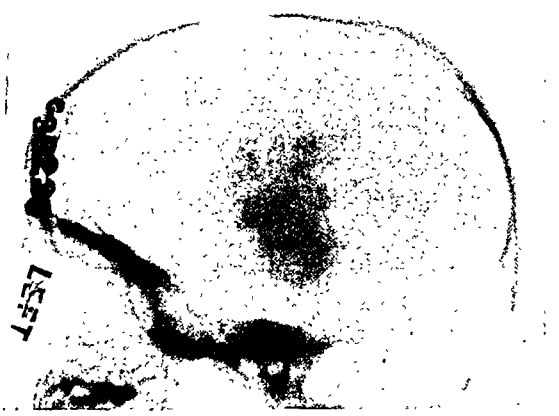


Fig. 4. Case 4, aged 7 years. Lateral view of the skull showing early changes. Beginning perpendicular striation of diploë in posterior portion of the parietal bones.

der the more general term "Von Jaksch's anemia."

HISTORY

Cooley and Lee (5), in 1925, described a series of five cases of anemia, with splenomegaly and peculiar bone changes, in children. In 1927, Cooley (4) classed these cases as a peculiar type of Von Jaksch's anemia. Later, in 1927, Cooley, Witwer, and Lee (7) published case histories of their original five cases and two additional cases studied elsewhere. The condition was termed "erythroblastic anemia" by Cooley (3) in 1928 At that time he clearly differentiated what he considered to be three hemolytic anemias of childhood, and emphasized that congenital hemolytic icterus, sickle-cell anemia, and erythroblastic anemia were all rather closely related, not only in symptomatology, but probably also in fundamental etiology.

Reynolds (29) appears to be the first radiologist to clearly describe the roentgen-ray appearance of the bones He examined the cases described by Cooley in 1925. Karshner (22), in 1928, reviewed the roentgenograms of Cooley's fifth case and added her findings in two additional cases of erythroblastic anemia. Friedman (12), in the same year, described the roentgen-ray findings in three cases and the necropsy findings in a fourth case. The title of his paper was, "Osseous Changes in Hemolytic Icterus," but a study of his case reports demonstrates that his patients had all the characteristic findings typical of the clinical group termed "erythroblastic anemia." Hitzrot (18), in 1928, reported four cases, one of which had been reported by Stillman (36) as Von Jaksch's anemia in 1918. In the same year Whipple, Reeves, and Cobb (39) added two more carefully studied case reports. In 1930, Whitcher (40) reported three cases, but did not include roentgen-ray studies. Diamond (9), in 1929, mentioned

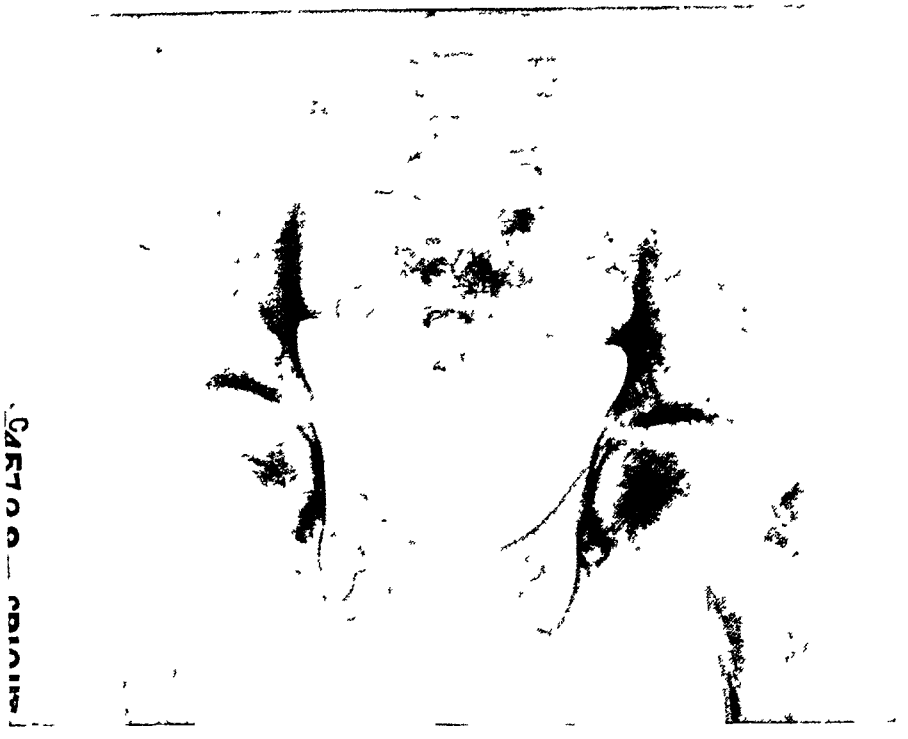


Fig 5 Case 1, aged 15 years Trabeculations throughout the pelvis and upper femora

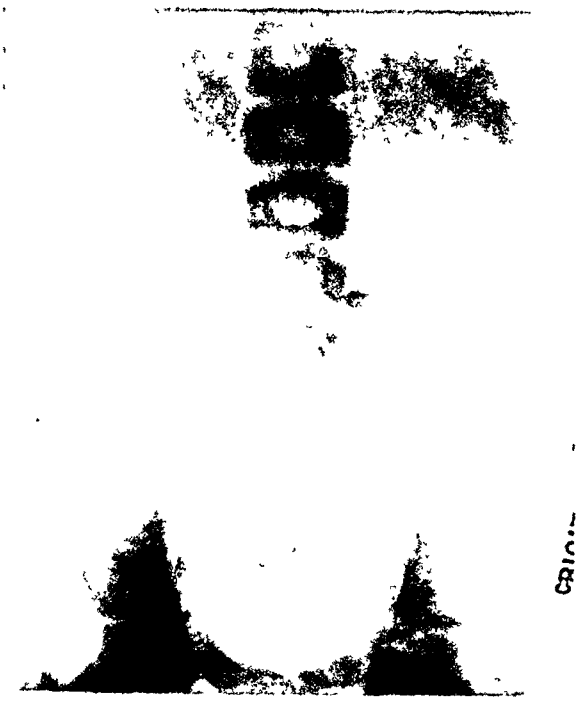


Fig. 6. Case 1, aged 15 years. Trabeculations of the lower dorsal and lumbar vertebrae.



Fig. 7. Case 3, aged 4 years. Striations throughout the pelvic bones.

the three anemias noted by Cooley in 1928. He termed them "congenital anemias," instead of "hemolytic anemias" as designated by Cooley. Diamond reviewed fourteen cases of the erythroblastic type, one of the sickle-cell type, and four of the congenital hemolytic type. Vogt (38) at the same time correlated the clinical, pathological, and roentgenologic findings and demonstrated changes in the skull and long bones.

PATHOLOGY

At least six necropsies which included studies of the bones are known to have been performed, and several other studies of spleens removed at operations can be found in the literature. A discussion of the fibrotic changes found and their similarity to other splenomegalies found in children need not be discussed here. In general, the necropsies agree in the description of the gross findings in the skull and long bones. Cooley, Witwer, and Lee (7) presented the necropsy findings of skull, long bones, and viscera of two of Cooley's early cases. Friedman (12) added a third, and Karshner (22) mentions a fourth necropsy. One of Diamond's series came to autopsy. Schultz's (33) necropsy of a case, reported clinically by Cooley, is fairly representative of them all, and his findings are of particular interest to the radiologist.

The fundamental changes noted in the long bones and the skull vault were similar in character, in spite of the differences in osseous development. The long bones showed thinning of the cortex. Schultz states that there was a partial replacement of cellular marrow by cellular connective tissue of the osteoid type, and he interpreted these changes as due to an aplasia of the erythroblastic marrow and a hyperplasia of the leukoblastic marrow. The actual cellu-

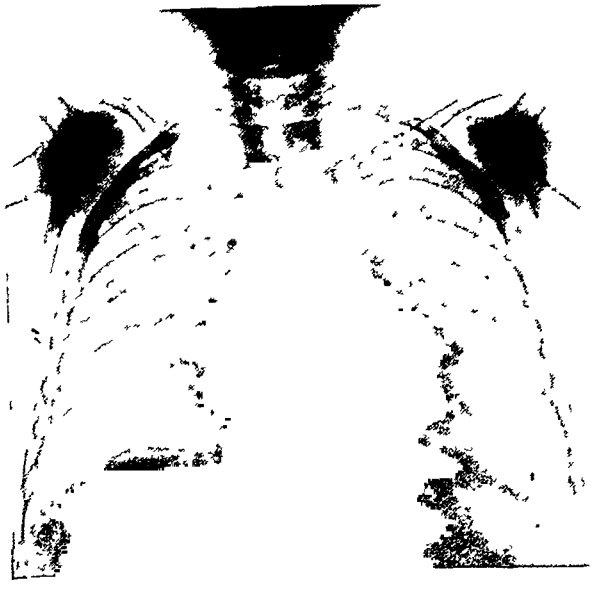


Fig 8 Case 3, aged 4 years Trabeculations of the ribs, scapulæ, and clavicles These are shown best on the original roentgenogram

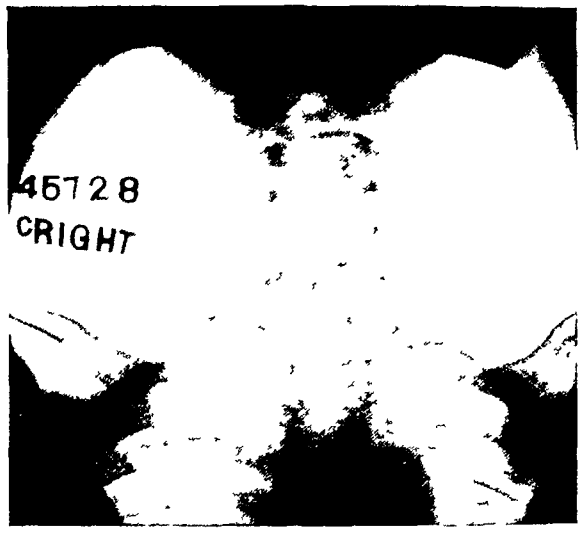


Fig 9 Case 1, aged 15 years Lower cervical and upper dorsal vertebræ and upper ribs demonstrate trabeculations

lar connective tissue of osteoid type was taken as evidence of beginning exhaustion of the hyperplastic process present.

The intra-membranous bones of the skull participated in the same hyperplasia of leukoblastic marrow as characterized the long bones The same absence of erythroblastic hyperplasia and increase in the amount of spongy trabeculated bone was observed in the frontal, parietal, temporal, and occipital bones.

Cooley believes that the changes in the bones of the skull are a part of the same process involving the hemopoietic system as a whole He explains that these changes in the bones are the result of the reaction of the marrow to prolonged over-stimulation, the marrow having been over-stimulated to compensate for the chronic hemolysis. The hyperplasia of the marrow begins before the cortex is firm enough to stop the overgrowth of the marrow In the earlier stages and less severe cases, the porous appearance in the roentgenogram seems to represent marrow hyperplasia In the terminal stages, the pronounced striation indicated replacement of the exhausted bone by new bone as found at necropsies. Cooley does not believe that bone change is primary.

In summary, it is important to state that necropsies performed independently, in different medical centers, agree that there is a—

(1) hyperplasia of the marrow of the long bones;
(2) general thinning of the cortex of the long bones;
(3) hyperplasia of the diploë of the bones of the cranial vault;
(4) thinning of both inner and outer tables of the skull;
(5) trabeculæ of connective tissue and osteoid tissue in the medulla of the long bones.

CLINICAL STUDIES

Full clinical case reports are to be discussed by another investigator Of the four cases studied, the syphilitic background in one case, and the question of a tuberculous history in a second, are worthy of detailed discussion After careful consideration, study, and laboratory investigations, the four patients roentgenographed have been considered by clinicians to be cases of

erythroblastic anemia. They all presented the fundamental picture of the condition described at the beginning of this paper.

Wollstein and Kreidel (41) have very recently presented excellent clinical studies of nine cases.



Fig. 10. Case 2, aged 11 years. Lateral view of lower humerus and upper radius and ulna demonstrating trabeculation near the metaphyses and thin cortices.

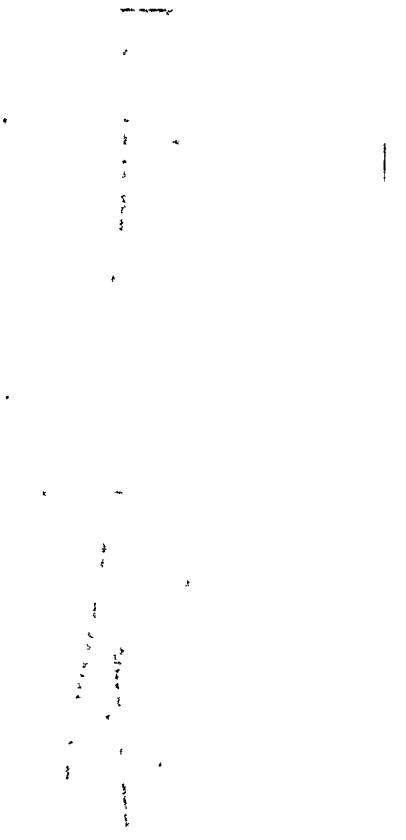


Fig. 11. Case 2, aged 11 years Antero-posterior view of same case.

ROENTGEN-RAY STUDIES

The results of the roentgen-ray examinations of the bones can be found in the literature. Diamond and Vogt present the results obtained in fourteen cases, Cooley seven cases, Hitzrot four cases, Friedman three cases, Karshner two cases, and Whipple and his co-workers two cases. We have reviewed the films of four cases studied clinically by the Department of Pediatrics, and roentgenologically by the Department of Radiology, Yale University, School of Medicine.

Case 1. Male. Two series of roentgenograms taken at age of 15.

Case 2. Female. Two series of roentgenograms taken at ages of 9 and 11, respectively.

Case 3. Male. Three series of roentgenograms taken at ages of 3 and 4, respectively.

Case 4. Male. Four series of roentgeno-

grams taken at ages of 5, 6, and 7, respectively.

The series enumerated above were by no means complete roentgen-ray examinations of all of the bones of the body, because at the time of these examinations the diagnosis of erythroblastic anemia had not been established. More complete examinations have been made when possible. One child died and a necropsy was not obtained. Two of the dispensary patients have, so far, failed to co-operate and to return for further studies.

Pathologic change was not noted in all of the long bones roentgenographed

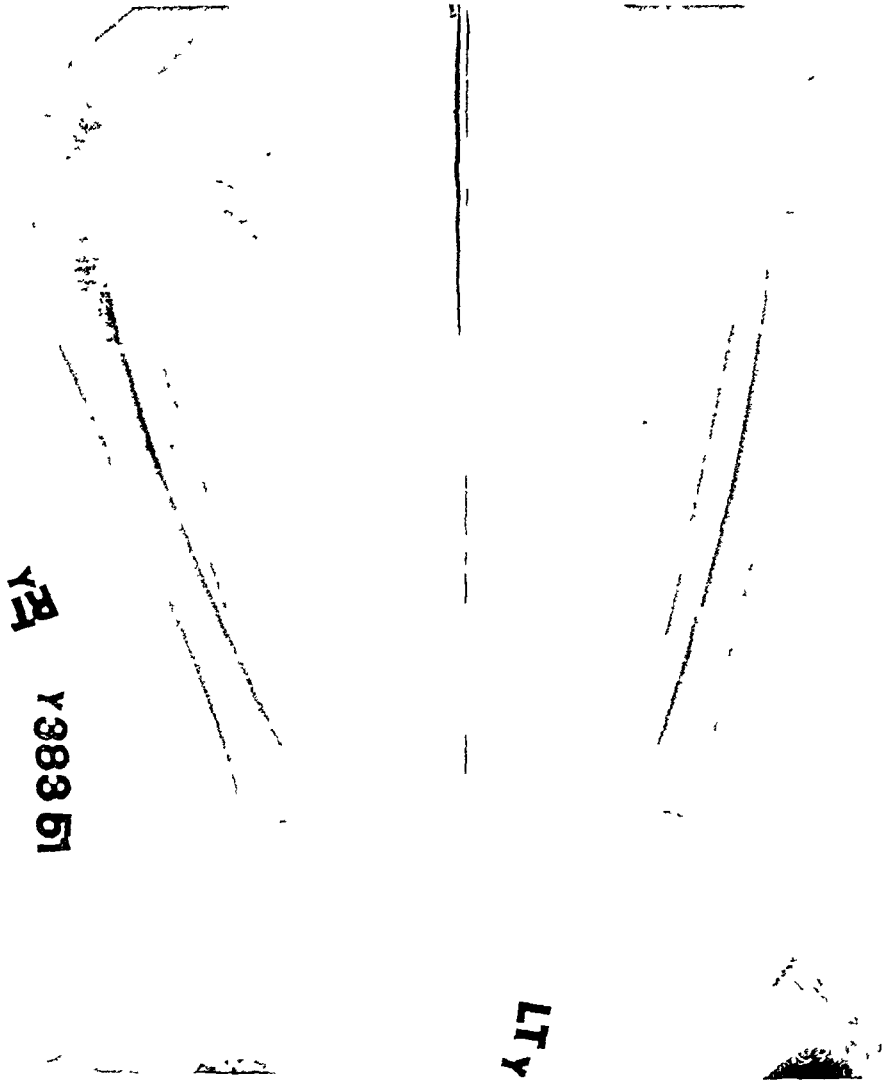


Fig 12 Case 3, aged 3 years. Lateral view of both tibiæ and fibulæ, demonstrating thin cortices and transverse striations in the metaphyses

All the skulls radiographed demonstrated changes in the cranial vault, while several of the spines, scapulæ, and pelvic bones demonstrated definite changes. The ribs of several cases showed evidence of pathologic change.

A careful study of the roentgen-ray find-

ings noted in the literature and the four cases studied by us demonstrated—

1. Thickening of the medullary portion of the frontal, parietal, temporal, and occipital bones.

2. Thinning of the inner and outer tables of the bones of the skull vault.

3. A mottled appearance of the medullary portion of the cranium in the earlier stages. Several authors have described this as a spongy or porous appearance

4. Striations perpendicular to the tables of the skull in the later stages. The diploë gradually assumes a thickness equal, at times, to as much as four times its normal width.

5. Irregular trabeculations in the pelvis, vertebræ, ribs, clavicles, and scapulæ. This

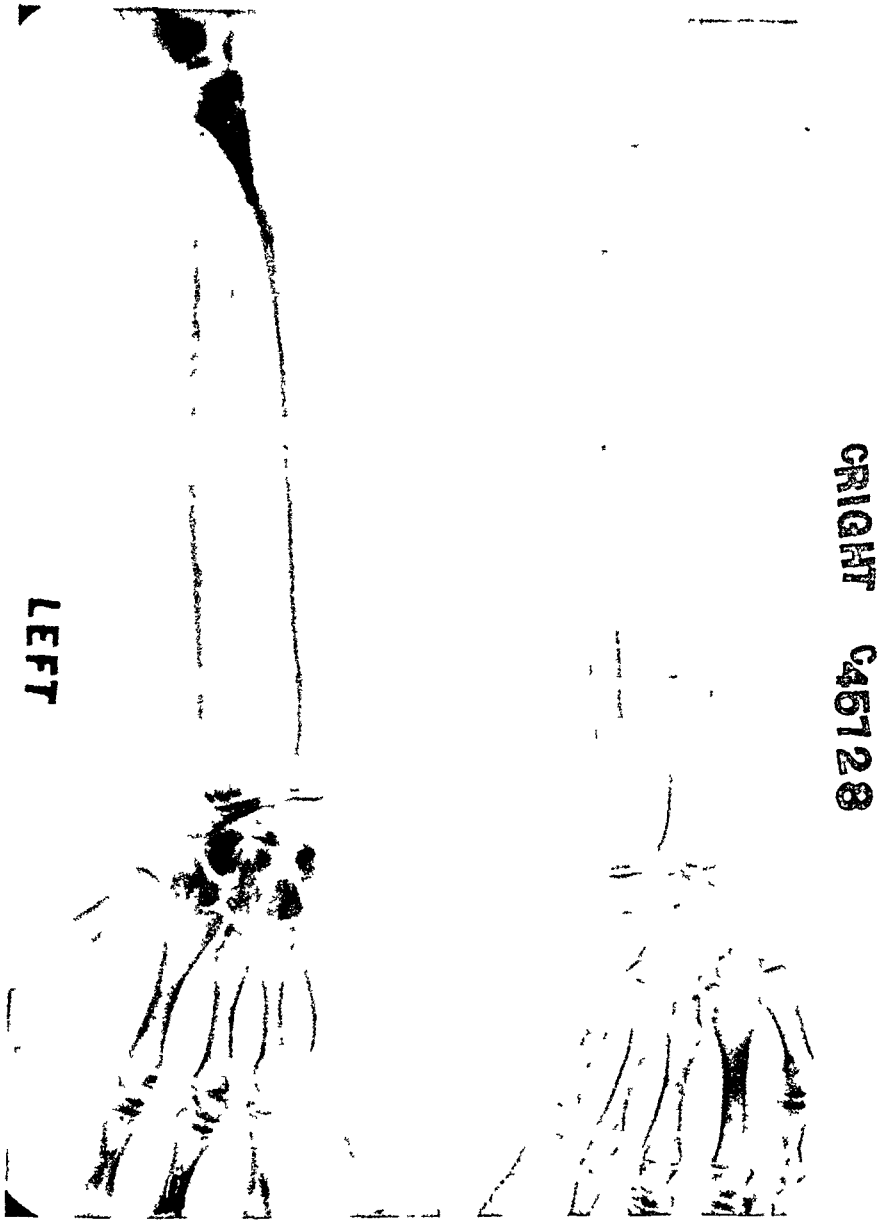


Fig 13 Case 1, aged 15 years Irregular striations of the metaphyses No widening of the metacarpals is demonstrated

appearance is apparently due to new bone formation. There is evidence of slight rarefaction within the trabeculated areas, which has been described as a porous appearance. This is evidently due to localized destructive bone changes.

6. Definite thinning of the cortex of the long bones. This is an important and rather constant finding.

7. Rarefaction of the shafts of the long bones. The medulla of the long bones demonstrates increased radiability. This characteristic is well illustrated and described by some authors as a transparent medulla.

8. Trabeculations of the medulla of the long bones, more marked in the metaphyses. They appear as sharp and finely pencilled trabeculæ near the ends of the bones. Some authors have described them as trabeculations perpendicular to the cortex, but this we have found not to be the rule. The trabeculation may affect all of the bones of the body.

9. Normal joints. No pathologic change has been noted to involve the joint surfaces or spaces.

10. No periosteal elevation. Periosteal involvement is not recorded.

11. Absence of pathologic fractures. Spontaneous fractures were not noted in any of our cases, nor did any of the cases reviewed in the literature mention them. In spite of the evidences of bone destruction, the rapid compensatory bone production following has evidently prevented pathologic fractures.

Several authors have noted widening of the metacarpals and metatarsals and rarefaction of their shafts. While these changes probably do occur, we have not found them in our cases.

A few investigators describe a thinning of the inner table of the skull vault, and a thickening of the diploë and outer table of the skull. The necropsies performed demonstrate that both the inner and outer tables are thinned, and a study of roentgenograms of the skull seems to confirm the necropsy findings. Occasionally it is difficult to visualize the outer table because of its extreme thinness.

DIFFERENTIAL DIAGNOSIS

At the present time, we cannot state that the roentgen-ray findings in the bones are characteristic of erythroblastic anemia alone. Two other anemias, characterized as hemolytic by Cooley, namely, sickle-cell anemia and congenital hemolytic anemia, are said to present similar bone changes. Diamond (10) states that the changes are similar but not as marked. He says in part: "The roentgenologic changes are not characteristic of any one disease but may result from any process in which there is a moderately severe and prolonged anemia in infancy or childhood, with resultant hyperplasia of the bone marrow tissue. The only cases which fulfill this requirement that I know of are those of erythroblastic anemia, sickle-cell anemia, and congenital hemolytic anemia."

Grulee (16) and Gänsslen (13) concur in the opinion that bone changes are not characteristic of erythroblastic anemia. Cooley insists that they are, however, indicative of a chronic hemolytic process belonging to the general group of hemolytic icterus. He points out definitely that non-hemolytic anemias, rickets, and syphilis show no bone changes similar to those noted in the hemolytic anemias.

The presence in the blood picture of the characteristic cell in sickle-cell anemia would serve effectually in establishing a diagnosis. With but two exceptions, all cases noted in the literature occurred in patients of negro or mulatto extraction.

Congenital hemolytic anemia is not limited to children of Mediterranean ancestry. There are more reticulated red blood cells in

this disease than in any other. Increased fragility of erythrocytes to hypotonic salt solutions is common. The spleen demonstrates only slight enlargement, even after marked progression of the disease. Removal of the spleen brings about marked improvement—hemolysis stops and anemia and jaundice disappear.

The clinical and laboratory findings of the three anemias designated as hemolytic in type are, therefore, sufficiently different to clearly distinguish them.

All the diseases of infancy and childhood which present enlargement of the spleen must be differentiated from erythroblastic anemia. The anemia described by Von Jaksch in 1889, the chief characteristic of which was the large number of immature cells of all types in the blood, is now regarded by many observers as a very doubtful clinical entity. Cooley (4) considered erythroblastic anemia to be a peculiar type of this disease, as late as 1927. He has since that time altered his opinion.

The bones in erythroblastic anemia do not demonstrate periosteal elevation. In leukemias, periosteal elevation of the long bones is usually noted. The character of the leukocyte counts is, if course, important clinically in establishing the type of leukemia and in following the progress of the disease.

Karelitz (21) reported a case of myeloid leukemia with periosteal elevation and some cortical erosion.

Rolleston and Frankau (30) have described thinning of compact bone, thinning of the ribs, and enlargement of cancellous spaces in a case of acute lymphatic leukemia. Pendergrass and Bromer (27) have noted an increase in the width of the zones of temporary calcification in this disease.

Gaucher's disease (8) presents enlargement of the spleen. Splenic puncture and demonstration of the peculiar endothelial cell masses (Gaucher cells) may establish a

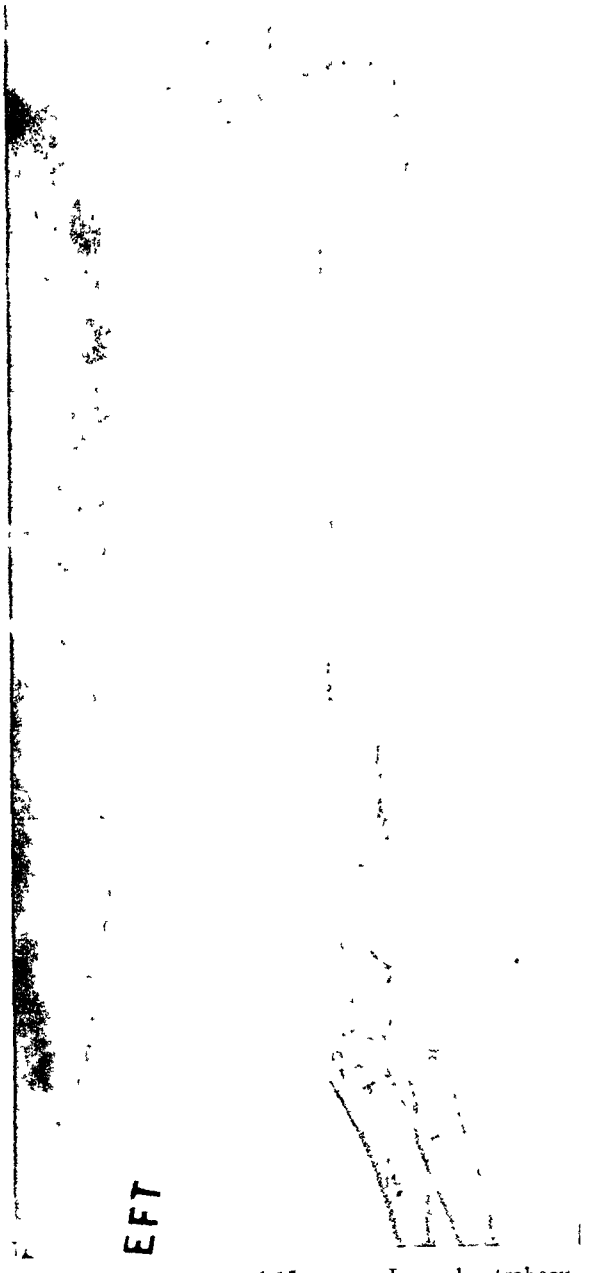


Fig. 14. Case 1, aged 15 years. Irregular trabeculation of metaphyses at elbow. No joint involvement. No periosteal elevation.

diagnosis. There is usually a leukopenia. According to Steiner (34), Pick believes it to be a skeletal disease. Necropsy findings have demonstrated Gaucher cells in the bone marrow, liver, spleen, and lymph nodes. The long bones have been expanded and their cortices thinned; periosteal involvement and pathologic fractures have been noted,

and a lumbar kyphosis and compression of vertebral bodies have occurred. No changes in the skull have been observed.

Fischer (11) has made a careful study of the roentgen-ray findings in Gaucher's disease. He has presented three cases in which the disease was confirmed by histologic sections following splenectomy. Of seven cases, six showed distention and flask-shaped deformity of the distal end of the femur, while in five cases a rarefaction of the medulla of the femur was also demonstrable. The deformity of the distal end of the femur is regarded by Fischer as typical of Gaucher's disease.

Steiner (34) found nine cases of the splenohepatomegaly of Niemann Pick in the literature. The progress of the disease was rapid. Splenic punctures demonstrated typical foam cells. A peculiar case in a girl of five was observed, with cranial and skeletal bone involvement.

The onset of symptoms in Banti's disease (20) occurs as a rule later in childhood, and it should not be confused with erythroblastic anemia.

There are several cases of thrombotic and parasitic splenomegaly reported in the literature, occurring in early childhood, so unusual that an attempt to differentiate them would be confusing.

Holmes and Ruggles (19) state that a true periostitis usually appears as a deposit of new bone upon a cortex of normal appearance, and that periosteal new bone formation may be due to any form of irritation. In early life, syphilis, rickets, and scurvy present periosteal change in the bone which in itself serves to differentiate them from erythroblastic anemia. All three present different endochondral changes in the long bones, which aid further in distinguishing them.

The tuberculous and pyogenic processes which usually occur later in childhood present changes characteristic of bone and cartilage destruction which have been fairly well established. The periosteal changes so often noted in the pyogenic forms of destruction readily exclude erythroblastic anemia.

Pathologic changes in skull roentgenograms must be differentiated in various diseases.

The skull is frequently involved in syphilis, most often the bones of the vault and face. They may become affected in any of the stages of the disease. According to Schüller (32), the formation of syphilitic granulation tissue has its origin in the periosteum, dura, mucous membrane, or bone marrow. The outer table of the frontal, temporal, and parietal bones often demonstrates localized areas of increased density due to the deposition of granulation tissue between the periosteum and outer surface of the bone. The medullary spaces of the diploë are widened, so that roentgenograms demonstrate a rarefied appearance.

Gummata of the skull produce an appearance of irregular bone destruction and surrounding areas of sclerosis. Occasionally there is formed a sclerosis of the diploë, progressing in some areas to a condition of eburnation, along with massive thickening of the bone. The manifestations of hereditary syphilis in the skull are too well known to deserve mention here. In erythroblastic anemia the perpendicular striations in the diploë and thinning of both tables throughout the cranial vault should not be confused with the irregular syphilitic changes described by Schüller. Early changes, it is true, cannot be differentiated by roentgen-ray examination.

Hyperostoses, localized to certain portions of the cranial vault, have been noted in cases of brain tumor. The pressure of an endothelioma of the dura mater against the vault is often associated with a definite clinical history and symptoms.

Under the heading "hyperplastic osteitis," Schüller considers syphilitic hyperostoses,

hyperostoses occurring in icterus, the ossifying osteitis occurring in leukemia, malignant tumors, chronic arsenic and phosphorus poisoning, chronic alcoholism, pregnancy, and osteomalacia. He admits that not much is known concerning the skull changes noted in these conditions with the possible exception of syphilis. On the other hand, it is well known that osteitis deformans and osteitis fibrosa produce widespread bone changes. Practically all these conditions are unknown in infancy and early childhood and, therefore, need not be considered.

The majority of primary and metastatic tumors of the skull are not found in infancy and early childhood. Chloroma, however, does occasionally present an appearance easily confused with the skull of erythroblastic anemia. Karshner (*22*) states that although chloroma was formerly classed with tumors it is now thought to be related to, if not a form of, acute leukemia. She states that the clinical symptoms, blood picture, and pathologic findings of the two are frequently identical. Schüller (32), Allison (2), Gould and Le Wald (15) consider it as an entity. The localization of bone proliferation about the orbit, the widening of the sutures of the skull, irregular mottling of the skull vault and of the shafts of the long bones, the periosteal proliferation, and the formation of greenish infiltrations of the lymph nodes are said to be diagnostic of chloroma. Because of the difference of opinion among pathologists concerning this condition a more definite differentiation cannot be presented at this time. In two instances when films of skulls, clinically and roentgenologically diagnosed erythroblastic anemia, were shown, the possibility of chloroma was suggested by physicians present. A complete examination of all of the bones of the skeleton is, therefore, advised.

CONCLUSIONS

1. A review of the literature reveals forty-seven cases of the clinical entity termed "erythroblastic anemia."

2. Roentgen-ray examinations in erythroblastic anemia demonstrate peculiar changes in the bones of definite value in confirming the clinical diagnosis.

3. The roentgen-ray findings in the bones in four additional cases of erythroblastic anemia are presented.

4. Necropsies of six cases have been made in various medical centers. Necropsy reports tend to confirm roentgen-ray findings.

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VISUALIZATION OF THE PELVIC VISCERA

IODIZED OIL AND PNEUMOPERITONEUM COMBINED IN GYNECOLOGY[1]

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WE have used pneumoperitoneum in our study of the female pelvic viscera since 1923, utilizing the transuterine or transabdominal route of inflation in 470 patients. In 150 of these, iodized oil (lipiodol) has been employed in combination with gas for intra-uterine instillation. There has been no accident or untoward result in this series of patients, and in none of those who were operated upon subsequent to the diagnostic procedure was evidence of peritoneal irritation or inflammation found. This can probably be attributed to the careful selection of patients, the judicious choice of route of inflation, careful asepsis and antisepsis, and after-care.

Discomfort, which more or less attends this mode of examination, has been minimized by the adoption of a routine which has been followed for some time, almost without exception. The patient is hospitalized, and given a low soapsuds enema about one hour before examination. This is followed by a hypodermic injection of 1/6 grain of morphine and 1/150 grain of scopolamine one-half hour before the examination. The eyes are covered with a towel, and attendants are instructed not to converse with or disturb the patient in any way. She is kept quiet in a darkened room and is disturbed only to void urine just before being transported to the X-ray room on a cart and placed in position on a table especially constructed for pneumoroentgenography (1).

The following routine, described in our previous publications (2), is then carried out. Briefly, it consists of:

(*a*) Dorsal lithotomy posture, with hips slightly elevated;

(*b*) Insertion of modified Graves' vaginal speculum;

(*c*) Disinfection of vagina and cervix with 2 per cent mercurochrome solution;

(*d*) Introduction and adjustment of a special self-retaining canula set (3);

(*e*) Pneumoperitoneum induced by the transuterine or transabdominal route, the method of choice being determined by the gynecologic condition;

(*f*) Intra-uterine instillation of 5 c.c. of iodized oil through self-retaining canula;

(*g*) A single roentgenogram, made in the dorsal posture;

(*h*) The patient at this stage placed in the partial knee-chest position, and, with the instrument remaining *in situ*, the instillation of an additional 2 c.c. of iodized oil;

(*i*) The patient now lowered to the final position on the table and films taken (1);

(*j*) After an interval of five minutes the taking of another film;

(*k*) In some instances, where tubal patency is still in doubt, the taking of additional films eighteen or twenty-four hours later, the instrument in this case having been removed.

The after-care of the patient is important. She is transported back to bed on the cart, care being taken that her head and shoulders are kept lowered, and in case upper abdominal discomfort exists, the hips are elevated. The patient is kept flat in bed for from eighteen to twenty-four hours to avoid discomfort on arising. Although some patients do complain of minor abdominal discomfort and shoulder pain for a day or two, the great majority go about their

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Fig. 1-*A*. Right hydrosalpinx containing "pearl cluster" of lipiodol.

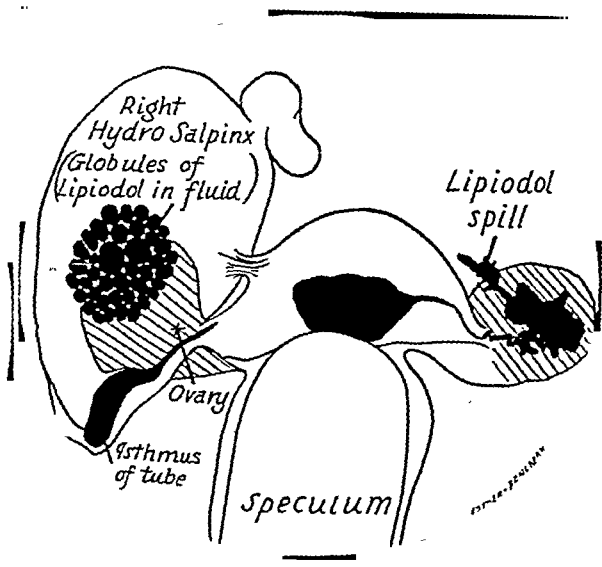


Fig. 1-*B*. Explanatory diagram of film shown in Figure 1-*A*.

duties undisturbed. We have seen no general systemic or local reactions, such as fever, vomiting, bladder disturbances, or other evidence of peritoneal inflammation, following this routine.

IODIZED OIL *vs.* THE COMBINED METHOD

We have been interested in statements in the literature reporting on the diagnostic value of iodized oil alone in pelvic diagnosis (4, 5, 6). That fibroids, cysts and other pelvic tumors can readily be diagnosed by this means, has not been verified in our experience. We have previously shown and emphasized, however, that these same conditions can be clearly recognized and differentiated by pneumoperitoneum (7). In order to estimate the diagnostic value of the methods separately and in combination, we have compared roentgenograms in which iodized oil alone has been used, and also in combination with gas, in the same patient. In no instance were the films of the intra-uterine lipiodol instillation alone of greater value than to show the size and shape of the uterine cavity, and the filling, or failure to fill, of the tubes. Peritoneal spill was not commonly present, probably because only 5 c.c. of the oil was used at first and because the film was taken promptly. Even when spill is present to a marked degree, we are unable to attribute much value to this method, other than to determine tubal patency, size and shape of the uterine cavity, and points of tubal obstruction. Even this latter bears careful interpretation since the arrest of the iodized oil at any point in the tube may be caused by spasm as well as by pathologic stenosis (8).

On the other hand, the films in the partial knee-chest posture after combined pneumoperitoneum and intra-uterine lipiodol instillation rarely failed to show the exact pelvic status clearly. It is uncanny how completely and how accurately one may often record the pelvic pathology in the roentgen film. The combined use of lipiodol and pneumoperitoneum permits one literally to look into the pelvis without incision or the use of the abdominoscope.

DIAGNOSIS OF HYDROSALPINX

The recognition of closed Fallopian tubes offered one of the first and most obvious uses of a contrast medium in gynecology. Large accumulations of the opaque oil in the region of the distal ends of the tubes could be easily interpreted. However, some cases yielded puzzling results as to whether the oil was retained in the tubes or spilled into the peritoneal cavity, because regular globules of the oil, resembling pearls, were to be seen in the pelvis. One of the most striking instances of this which we have seen is illustrated in Figure 1-*A*.

CASE REPORT

Mrs. F. G., aged 25, was seen July 10, 1927, because of a sterility problem. Her chief complaints were menorrhagia, dysmenorrhea, and backache. Her last period had been June 20, 1927. Hühner's test (on July 16th), two hours post-coitum, revealed many motile spermatozoa in the vaginal pool and also in the aspirated endocervical mucus. She failed to menstruate in August but menstruated September 3d, profusely, for 48 hours. Examination (on September 8th): Uterus and adnexa negative (patient unfavorable for bimanual examination because of rigidity). Patency test was performed November 9, 1927, five days after cessation of menses, during which the manometric pressure rose to 200 mm., but dropped promptly to 80 millimeters. Transuterine pneumoperitoneum was induced, using 1 liter CO_2, and 5 c.c. lipiodol was instilled into the uterine cavity. Films were taken in the prone and partial knee-chest postures. The films disclosed the following: At least one tube patent, the gas passing readily into the peritoneal cavity. The left was evidently patent as the right was occluded. Both ovarian contours were within the range of normal. The right ovary, while of normal size, was somewhat dense. There was a large mass in the right posterior half of the pelvis, the size of a lemon, which had the appearance and the consistency of a cyst. The right tube was dilated immediately beyond the isthmus, for a distance of approximately 2 cm., although the interstitial portion appeared of normal size. The lipiodol had collected in the right half of the pelvis and just above the dilated portion of the tube, in globules the size of peas, all massed together like a pearl cluster. From its location within the confines of the cystic mass, and from the fact that the opaque medium was in globules which had not coalesced, a tentative conclusion was drawn that the globules of lipiodol were within the cystic mass, having been forced through a small opening in the tube. Hydrosalpinx had to be considered.

Subsequent films, taken twenty-four hours later, showed a complete absorption of the gas, but the lipiodol, which previously presented the appearance of a "pearl cluster," had consolidated into one dense mass instead of being distributed throughout the peritoneal cavity. This appeared to confirm the previous findings that the opaque substance entered the cystic mass.

The patient was re-examined bimanually the following day, under gas anesthesia, and the mass palpated, the findings being corroborated by a colleague in consultation. Patient was operated on November 12, 1927.

Operative report.—The uterus and left adnexa appeared normal. The right tube was greatly enlarged, pear-shaped, transparent, containing fluid and an oily substance. This was unquestionably the lipiodol which had been instilled through the uterus a few days previously. There was no evidence of intraperitoneal irritation from the lipiodol spilled through the opposite tube. The right ovary contained a hemorrhagic corpus luteum. The hydrosalpinx and right ovary were removed.



Fig. 1-*C* Hydrosalpinx after surgical removal. Note retained coalesced lipiodol.

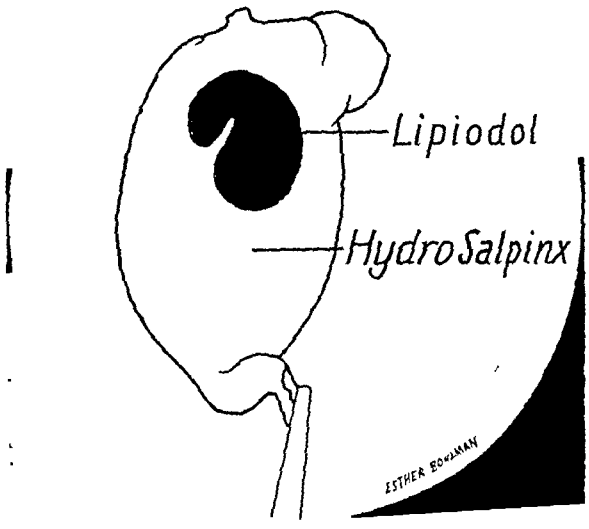


Fig. 1-*D*. Explanatory diagram of Figure 1-*C*.

REPORT OF THE PATHOLOGIC LABORATORY

Hydrosalpinx—parovarian cysts of the Fallopian tube.

Gross.—The specimen is a large, egg-shaped mass, measuring $9 \times 5.5 \times 5$ cm., and at one end is a curved piece of tube 3.5×0.5 cm., swelling to a diameter of 2.0 centimeters. From this point the diameter increases to 5.5 cm., and at the other end of this egg-shaped swelling are a number of adherent fimbriæ, close to which are two cysts 2.5 and 1.0 cm., respectively. The large cyst, apparently, is made up of a markedly distended tube, and the wall is parchment-like, with a smooth lining. This cyst is filled with clear fluid and at the bottom is 2 c.c. of a heavy yellow oily substance. In the isthmic portion, as seen from the inner portion of the cyst, is a large valve-like fold separating off a small cystic space from the main cavity. The two easily communicate and within the smaller cavity are a number of linear folds which course out into the main cyst. Where these join is a small opening through which a fine probe can be passed to the isthmic portion of the Fallopian tube, to a point about 1.0 cm. from the end of the tube. At the other end of the cyst there is no apparent opening to the fimbria.

Microscopic.—Sections from the thin wall of the tube show a thin, fibrous tissue membrane, lined on one side by a single layer of flattened epithelial cells. The epithelial cells of the fimbriæ of the tube are large and have a relatively clear cytoplasm. While the lining of the large cyst resembles that of a parovarian cyst, it probably represents the wall of a markedly distended tube.

The post-operative condition was satisfactory.

In this case the interpretation was especially difficult for the following reasons: (1) The "pearl" formation was unilateral; (2) the opposite tube was clearly patent to both CO_2 and to lipiodol, the latter appearing unmistakably as a "spill" on all of the films; (3) the cystic mass on the side where

the "pearl" formation occurred greatly resembled an ovarian cyst.

In the study of the films it was granted that the oil was definitely in a fluid medium, this causing it to assume the pearl-like appearance. We reasoned that if this fluid was inside the cystic mass, and contained the oil as well, then it was not likely to be an ovarian cyst, for the ovary has no portal of entry, unless there be a forced tubo-ovarian connection. However, tubo-ovarian swelling had to be considered. Further examination and study of the films revealed a shadow corresponding to the ovary beyond the cystic mass. Finally, it was necessary to admit a diagnosis of unilateral hydrosalpinx, and this in the complete absence of history or other findings of an inflammatory lesion. It was by this process of elimination that the diagnosis of unilateral hydrosalpinx was made before operation, which diagnosis was substantiated at laparotomy, a congenital hydrosalpinx, non-inflammatory in nature, being found. One year after operation the patient became pregnant and was delivered, in June, 1929, of a full term, normal child.

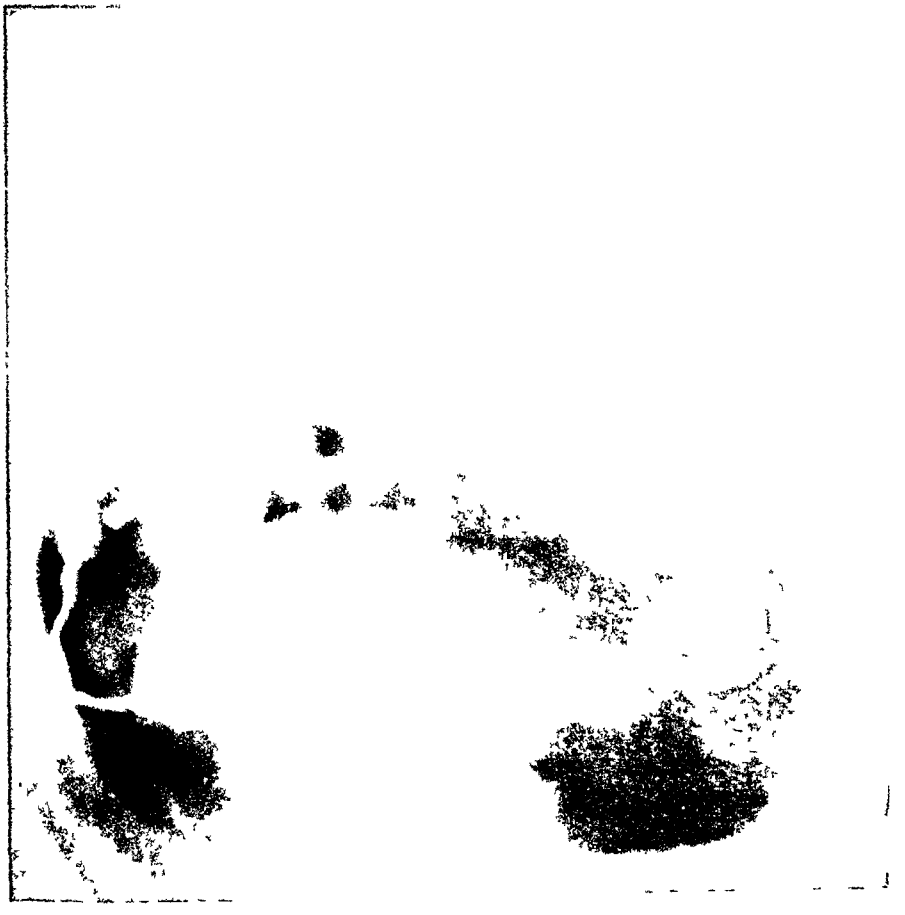


Fig. 2. Septate uterus. Large gas-inflated tubo-ovarian cyst. (Courtesy of Dr. C. C. Doherty.)

When the oil takes the form of globules it is reasonable to assume that it has entered a fluid medium. When any oily liquid is caused to enter a fluid medium, being projected through a fine lumen such as a Fallopian tube, the oily compound is formed into globules by virtue of its different viscosity and surface tension, and rises or sinks according to its specific gravity. These globules do not readily coalesce and, there-

fore, it is not uncommon to find them accumulated in "pearl clusters" in a fluid medium. To decide whether this medium is enclosed fluid, as in hydrosalpinx, or fluid encysted in peritoneal adhesions, or whether the uterus inflate a tubo-ovarian cyst through a tubo-ovarian fistula. This case (Fig. 2) was confirmed by operation. An interesting feature was that the surgeon failed to find the cyst, but removed the ad-



Fig. 3 Arcuate uterus. Bilateral cysts (right dermoid). Tubal sphincter visualized on left

it is free intraperitoneal fluid, requires careful and studious interpretation. Without the additional use of pneumoperitoneum one can rarely be sure, and, even with the latter, a series of follow-up films over a period of twenty-four hours may be needed to decide the issue We have seen this "pearl" formation in seven cases in hydrosalpinx. We have also seen the lipiodol divided into fine globules in free intraperitoneal fluid.

On the other hand, we have observed in one case gas which was introduced through nexa on the affected side. Subsequently the cyst was reinflated with gas through the uterine end of the tube and the tubo-ovarian origin of the cyst revealed. This was confirmed by the pathologist.

THE DIFFERENTIATION OF SMALL OVARIAN CYSTS FROM TUBAL AND TUBO-OVARIAN SWELLINGS

This group presents a very picturesque set of films. The tubes fill quite normally with iodized oil and may or may not show intra-

peritoneal spill, but previous examination will have shown small (3-6 cm. size) masses palpable on one or both sides. In the absence of pneumoperitoneum in this group, we have never found the films of diagnostic value except in a negative sense, *i.e.*, by eliminating tubal pathology.

On the other hand, by the combined method we have been able readily to diagnose unilateral and bilateral ovarian cysts, and to differentiate dermoids from simple cystomata. In several cases right dermoid and left simple cyst were shown on the film and found later at laparotomy. The accuracy and completeness with which the pelvic status appears on the roentgen film in these cases is truly remarkable. One instance of this is illustrated below.

Mrs. S. D., aged 24, had been married two years and was in her first pregnancy. The uterus appeared about the size of a three and one-half months gestation. On November 19, 1927, she spontaneously aborted a small fetus and placenta, the latter showing the typical picture of early hydatid mole formation. The post-natal examination disclosed a uterus of normal size, with the right ovary definitely cystic. It was thought to be the theca lutein cyst so commonly found (usually bilateral) with hydatid degeneration, and the patient was advised that it would probably disappear spontaneously.

Because of the persistence of the cyst, a transabdominal pneumoperitoneum was induced June 7, 1928, and 5 c.c. of lipiodol instilled into the uterus. The films (see Fig. 3) disclosed bilateral cystic ovaries. The right ovary was larger than the left and contained a dense mass, suggesting dermoid cyst. The uterus was arcuate. Both Fallopian tubes contained lipiodol to the fimbriæ. At laparotomy (June 11, 1928) resections of a dermoid cyst from the right ovary and of lutein and follicular cysts from the left ovary were performed.

Tubo-ovarian masses are usually of inflammatory origin, and the tubal closure is commonly found in the interstitial or isthmal portion of the tube. If so, no lipiodol will be found in the tubes, but the characteristic triangular shadow of the uterine cavity will be seen. If the mass is unilateral, one tube may show filling to the fimbriated end, or even may show spill, depending upon the degree of pelvic inflammatory damage which has occurred as the result of the infection. These results are not invariably present, however, but as we have previously shown (8), unilateral tubal filling may be due solely to unilateral cornual spasm. It is advisable, in all cases where the findings may be misinterpreted, to take films at intervals of a few hours, over a period of twenty-four hours.

In this brief report, we have made no attempt to analyze our complete series, as the average films present no great diagnostic difficulty. The viscera are usually so clearly visualized by the combined method that the gynecologist and roentgenologist have little difficulty in harmonizing their opinions. As a rule the gynecologist must rely to a great extent upon bimanual palpation, which often leaves him with indefinite information as to the exact nature of a pelvic mass which he may find. As illustrated above, even in the presence of unusual pelvic pathology, we have been able to visualize the viscera and thereby establish an accurate diagnosis. With our increased experience in the use of combined iodized oil and pneumoperitoneum in gynecology, we feel that we may recommend this method as a safe and precise means of pelvic diagnosis.

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THE MEASUREMENT OF THE INTENSITY OF THE GAMMA RAYS OF RADIUM IN r-UNITS

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AFTER the unit of the roentgen-ray intensity, "one r," was accepted by the International Congress of Radiology, it was desirable to determine, again, whether this unit might also be used to measure the intensities of gamma rays of radium. The first attempt to measure intensities of both roentgen and radium radiation in terms of the same unit was made by Friedrich and Opitz (1), who employed the "electrostatic" unit. This investigation was unsuccessful for two reasons: (1) The gamma-ray intensities were not measured in e-units directly, but were calculated indirectly by a comparison of the erythema skin reactions produced by both types of radiation with those produced by the roentgen-ray intensities which had been measured in e-units; (2) The Friedrich "e-unit" in use at that time was not the present international r-unit.

In 1924, Glasser (2), using a modified e-unit, made a comparison of radium and roentgen-ray intensities. He found, by direct measurement, that 1 mg. el hr. = 1.69 e-units (or r-units) when using a radium pack of 4 cm. diameter and a filter of ¼ mm. lead plus 1 mm. brass at a distance of 2 cm. from the center of the radium capsule to the center of the ionization chamber. We now find that this value, obtained six years ago, agrees satisfactorily with the results obtained in our recent experiments, which were carried out with improved apparatus. This proves that the modified e-unit which was used at that time is practically identical with the r-unit of to-day. The results of our investigation are presented in this discussion.

In 1925 Lahm (3) discussed this problem. His results, however, were not quite accurate, particularly because he also made an indirect calculation of the r intensities by comparison of the erythema reaction of radium with that produced by roentgen rays. It will be shown in this paper that this indirect method of estimating gamma-ray intensities in r-units may lead to considerable error. From his experiments, Lahm drew the conclusion that 450 mg. el hr. = 600 r = 1 skin-unit dose with a radium preparation 1.5 cm. in length, filtered by 1 mm. of brass, at a distance of 1 centimeter. In other words, 1 mg. el hr. = 1.34 r-units. This value was accepted by other investigators (Jona, 4, and Neeff, 5), and recently was again used by Lahm (6), but it does not agree with our results.

Kessler and Sluys (7) have tried to make an absolute determination of the r-unit for gamma rays by employing a large air-ionization chamber constructed somewhat on the same general principles as that used for roentgen-ray measurements, though they have not published their results. Stahel (8) also made relative intensity measurements on gamma rays with a micro-ionization chamber; but his results are as yet unpublished. Recently Jona (9) presented some of the results of his investigations of the same problem. His values approximate those which we gave several years ago. Neeff (10), on the other hand, in a series of measurements on gamma-ray doses in r-units, arrives at conclusions which do not agree with our results.

With their condenser dosimeter which lends itself particularly well to this kind of

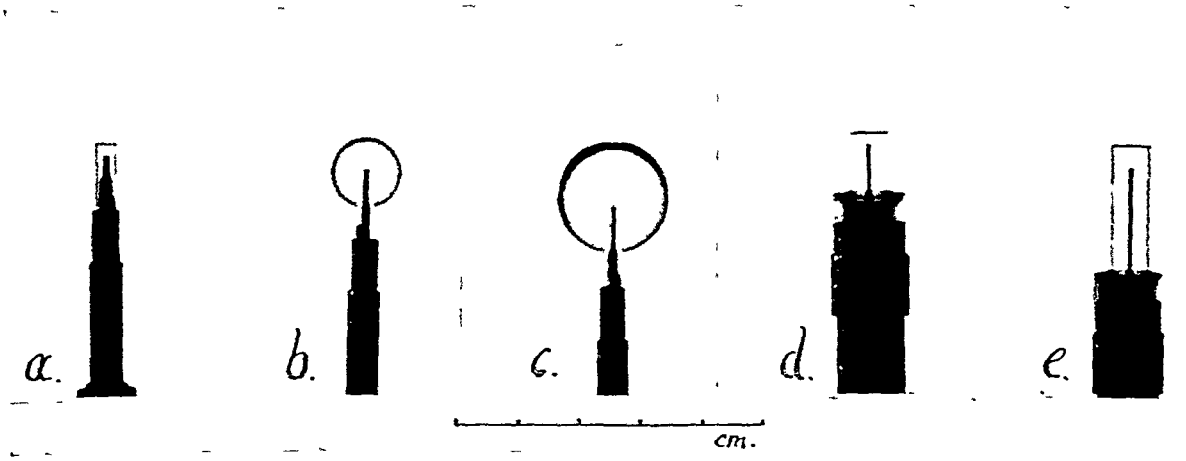


Fig. 1. Radiographs of the five chambers.

measurement, Glasser, Portmann, and Seitz (11) in 1927 took up the question of the measurement of the intensities of gamma rays in r-units. Their results, using different types of radium applicators, were published in several papers, and the r-values obtained were checked by the biological reactions. These experiments and this report are a continuation of this investigation.

In order to unify the problems of radium dosage, detailed descriptions of the measuring apparatus used in different laboratories are desirable. Therefore, we shall give a short description of our apparatus and procedure, together with the results we obtained in the measurement of gamma-ray intensities in r-units. The introduction of the r-unit into radium therapy is desirable because it may not only replace the other physical and biological dose units which are in use at the present time, but it also permits the direct comparison of r-doses in roentgen and radium therapy. Two questions, then, are of practical interest: (1) Can the r-unit be used to measure the intensity in radium therapy? (2) What is the relation between the biological effects of identical r-doses in roentgen and radium therapy? According to our results, we may answer that, under certain experimental conditions, the r-unit is a satisfactory measure of the intensities of the gamma rays of radium. A comparison of r-doses in roentgen and radium therapy shows that under certain conditions of radiation the number of r-units required to produce identical reactions on the human skin varies within wide limits. Under given technical conditions, 2,000 r-units with the gamma rays of radium produce the same erythema reaction as 600 r-units with roentgen rays.

MEASURING APPARATUS

In determining the intensities of gamma rays in r-units we employed the condenser dosimeter, previously described in detail (11). This instrument, which was built under the direction of V. B. Seitz, consists of a string electrometer and a condenser with ionization chamber attached. The condenser unit is first connected with the electrometer, and both are charged to a certain known potential, as indicated on the calibrated scale of the electrometer. The condenser unit is then removed from the electrometer, and the ionization chamber is exposed under given conditions to the gamma rays. After exposure of the chamber for a definite time, the condenser unit is again connected to the electrometer, and its loss of charge is read on the calibrated scale.

This loss of charge can be directly transformed into the intensity in r-units which acted upon the ionization chamber if the electric data of the total instrument (the volume and material of the ionization chamber and the time of exposure) are known. Undesirable effects which may be produced upon the condenser unit by the radiation, as well as effects upon the dielectric, have been minimized in this instrument, and may be controlled continuously by replacing the ionization chamber with a small amber cap and again exposing the condenser unit to the direct radiation. Even the penetrating gamma rays cause no loss of charge or other change than can be observed during the time ordinarily employed in making the measurements. Thus the objection against the instrument which recently was raised by Gueben (12) is nullified.

Gueben maintains that the conductivity of the dielectrica used in the instrument offers sources of considerable error. His statement that care must be used when certain types of dielectrica are exposed to penetrating radiation is correct; and we called attention to the possibility of changes in the conductivity of such dielectrica in an earlier publication (11). These errors are avoided by special selection of the dielectrica used and by the design of our instrument.

The ionization chambers employed in our experiments have also been previously described (11). They are of the air-wall type, and vary in volume from 1/35 to 2 cubic centimeters. Radiographs of the five chambers are shown in Figure 1. (These radiographs were made with Grenz rays of 10 K.V.) The small cylindrical chamber "a," of 1/35 c.c. volume, was used for making the measurements when in close proximity to the radium preparations. It is necessary to use such a small chamber for distances of less than 1 centimeter. For greater distances, the sphere chamber "b," of ½ c.c. volume, is preferable and can be recommended for almost all measurements of intensity when the distance is over 1 centimeter. In order to study some points of special interest measurements were also made with the sphere chamber we previously recommended, which has a volume of 2 c.c., and also with two cylindrical chambers the volumes of which are, respectively, ¼ and ½ cubic centimeter. We shall show later that there is some variation in the measurements of intensity made with these different chambers for distances up to 1½ centimeters. At distances greater than 1½ cm., however, the intensities are practically independent of the type of the ionization chambers investigated.

The determination of intensities of gamma rays in r-units by means of calibrated small ionization chambers is an indirect method. The direct method of determining intensities of gamma rays in r-units with a large air-ionization chamber, as done by Stahel, for instance, is difficult. We preferred the indirect method after we had previously (11) shown that there is a difference of only 5 per cent between ionization currents produced in a 1 c.c. graphite chamber and a 1 c.c. magnesium chamber when using radium rays filtered with 2 mm. of brass, or an equivalent thickness of other metals. In the well-known dosage formula

$$I = \frac{C \times (V_2 - V_1) \times p}{300 \times \text{vol.} \times t} \text{ r/sec}$$

the factor "p" is 1 when using any ionization chamber made of a material with an effective atomic number equivalent to approximately that of air, that is, 7.69. There is a possibility that hard gamma rays of radium produce certain unknown ionization effects which might be the source of errors in our indirect method of measuring the r-unit for gamma rays. According to our present information, however, our indirect method seems to lead to accurate intensity values of gamma rays in r-units.

The radium preparations used in our experiments were radium bromide and radium emanation, and they were of different sizes. Usually we employed preparations of 1.2 and 2 cm. length with a ½ mm. platinum or 2 mm. brass filter. Radium tubes with a 1.2 mm. brass filter were also used occasionally. According to our measurements, the differences between intensities of radium filtered with 2 mm. or 1.2 mm. of brass are slight. In order to determine the intensities measured with preparations filtered with brass and those filtered with ½ mm. of platinum, 2 mm. of lead, and ¼ mm. of steel, we measured the intensities for these different filters and collected the results in Table I, using a distance of 2 cm. from the center of the radium preparation to the center of the ionization chamber.

It will be seen from these data that the variation of the intensities of radium filtered with the 2 mm. brass filter or 1.2 mm. brass filter and the ½ mm. platinum filter are not great. The following measurements, which were usually made with the ½ mm. platinum filter, therefore, can easily be applied to preparations with a 2 mm. or 1.2 mm. brass filter if a small correction is made.

TABLE I

RADIUM CAPSULE 2 CM. LONG; 2 CM. DISTANCE FROM RADIUM TO IONIZATION CHAMBER (C)

Filter	Intensity in r/mg. el hr.	Relative Intensity
2.0 mm. brass	2.00	100
1.2 " brass	2.07	104
0.5 " platinum	1.94	97
2.0 " lead	1.58	79
0.25 " steel	8.8	440

One of the greatest difficulties in measuring the r-intensities of radium was found to be in the correct adjustment of the distance from radium preparation to ionization chamber or to skin. In all of our experiments this distance was taken from the center of the radium preparation to the center of the ionization chamber. In order that the condenser unit with the small ionization chamber would always be in the same relative position, we constructed a rigid holder with a stop, so that the distance between ionization chamber and radium preparation could be measured exactly by a vernier scale which has an accuracy of 1/20 millimeter.

The results which show the number of r

TABLE II

RADIUM CAPSULE 1.2 CM. LONG; ½ MM. PLATINUM FILTER; MEASUREMENTS MADE IN AIR

Distance in cm.	Measured Intensities in r/mg. el hr.			Calculated Intensities in r/mg. el hr.	
	Small Chamber (a)	Sphere Chamber (b)	Sphere Chamber (c)	$I=\frac{13.6}{d}\tan^{-1}\frac{0.6}{d^2}$	$I=\frac{8.0}{d^2}$
(0.15)				(120)	
0.4	31.3			33.5	50.0
0.5	22.2			23.7	32.0
0.6	16.9	14.3		17.8	22.2
0.8	11.0	9.3		11.0	12.5
1.0	7.6	6.6		7.4	8.0
1.2		4.8	5.7	5.3	5.6
1.4	3.9	3.6	4.1	3.9	4.1
1.6			3.2	3.1	3.1
2.0		2.1	1.9	2.0	2.0
3.0		0.92	0.91	0.90	0.89
5.0			0.32	0.32	0.32
10.0			0.08	0.08	0.08

per mg. el hr. and the effect of varying the distance are collected in Table II for the small ionization chamber "a," the small sphere chamber "b," and the large sphere chamber "c." They were obtained with a

tained from the measurements made at greater distances. In the last column are added the intensity values calculated by means of the law of inverse squares. These latter values refer to a point source, while

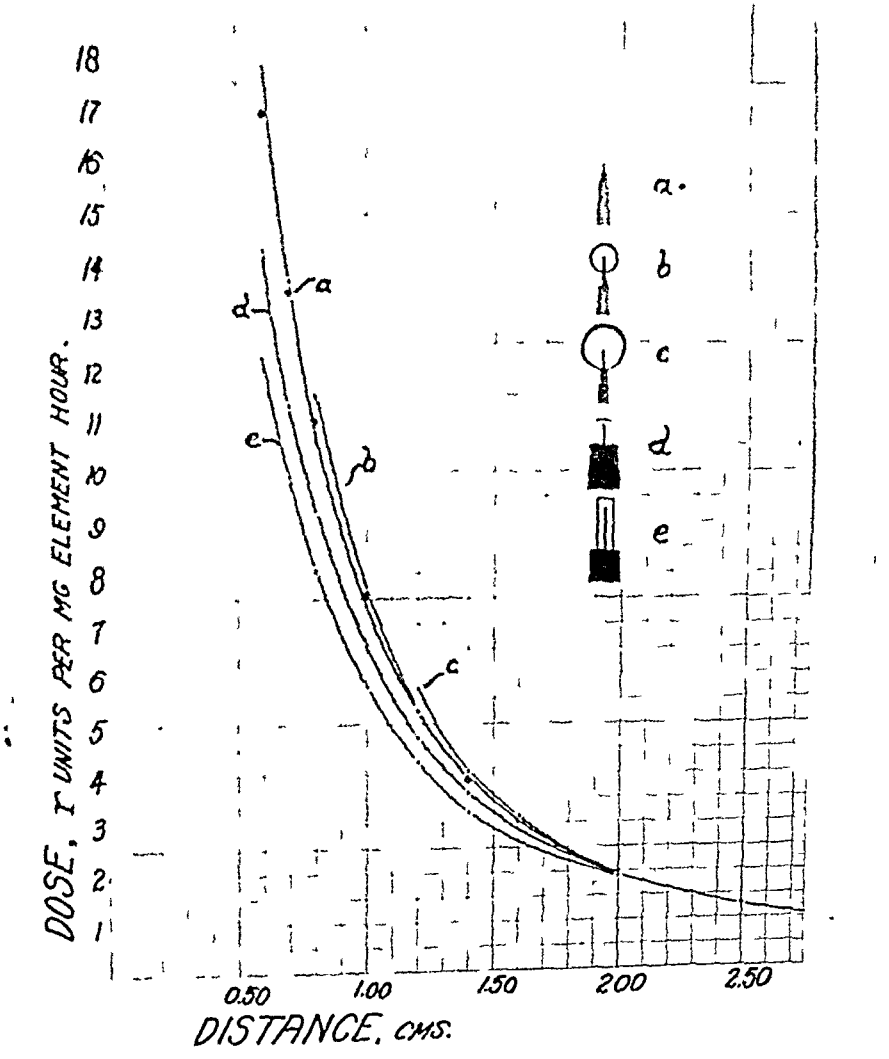


Fig 2 Intensities measured with the various ionization chambers

preparation of radium bromide, 1.2 cm. in length, 25 mg. el, and a ½ mm. platinum filter. The intensity values calculated by means of the formula

$$I = \frac{13.6}{d} \tan^{-1} \frac{0.6}{d^2}$$

are shown in the fifth column of the table. The constants in this formula have been ob-

the values in the fifth column take into consideration the length of the radium preparation. Of course, all of the radium intensities could be measured by means of the small ionization chamber, but at greater distances the ionization current in this chamber becomes small and the exposure time therewith too long. The larger chambers were

TABLE III

Distance in cm.	Measured Intensity in r/mg. el hr.	Skin-unit Dose in mg. el hr.	Skin-unit Dose in r
0.5	23.7	84.5	2000
1.0	7.4	270	2000
1.5	3.5	570	2000
2.0	2.0	1,000	2000
3.0	0.9	2,220	2000
4.0	0.5	4,000	2000
5.0	0.3	6,660	2000
7.5	0.14	14,300	2000
10.0	0.08	25,000	2000

TABLE IV

Distance in cm.	Measured Intensities in r/mg. el hr.		Commercial Chamber 6 c.c.
	Cylindrical Chamber (d) ¼ c.c.	Chamber (e) ½ c.c.	
0.6	14.3	12.2	
0.8	9.3	8.1	
1.0	6.6	5.8	
1.4	3.6	3.2	
2.0	2.1	1.9	1.7
3.0	0.92	0.96	0.79
5.0			0.32
10.0			0.08

TABLE V

RADIUM PACK, 4 × 4 CM. AREA; 4 MM. BRASS FILTER

Distance in cm.	Measured Intensity in r/mg. el hr.	Skin-unit Dose in mg. el hr.	Skin-unit Dose in r
2.0	1.74	1150	2000
2.5	1.13	1770	2000
3.0	0.82	2440	2000
3.5	0.64	3130	2000
4.0	0.49	4100	2000
4.5	0.39	5150	2000

used to determine the minimum distance at which this type of chamber may be used to give accurate measurements of the intensities.

The results show that at distances greater than 1½ cm. the intensities measured with various chambers are identical. For shorter distances, however, only those values can be used that were measured with the small chambers. It is interesting to note the great increase of intensity which occurs when the chamber is in close proximity to the radium preparation. For example, a change in distance of 1 mm. corresponds to a change in intensity of 30 per cent. It is necessary, therefore, to measure distances very accurately in order to observe small changes of intensity.

The data of special importance for practical use in therapy are collected in Table II, which also shows the values for skin-unit doses produced with the various radium applicators. We have selected figures to represent the skin-unit dose which are most accurate according to our present knowledge and experience. Attention has often been called to the fact that there is great variation in the reaction to the different skin-

unit doses of radium which have been proposed. The skin-unit doses reported by different authors, for instance, vary between 200 and 700 mg. el hr., with preparations filtered with approximately 1.5 mm. of brass at a distance of 2 centimeters. Within a certain limit the strength of the radium used in biological experiments plays a definite rôle, and we have, therefore, used preparations of about 100 mg. el hr. in our experiments. We found that the skin-unit doses which were cited in earlier publications and which were taken from Quimby's values (13) are somewhat too low. We increased these doses, therefore, and arrived at the data presented in the third column of Table III. If these values are multiplied by the r doses for the corresponding distance, the skin-unit doses are obtained in r-units. Since the values were found to be the same within a few per cent, we averaged the observed skin-unit doses and obtained the value 2,000 r for the observed skin-unit doses.

These values, which were obtained with a radium preparation of 1.2 cm. length and a ½ mm. platinum filter, can also be used for the 2 cm. preparation with the 1.5 mm. brass filter, with the exception of the intensity at short distances. The same values may be used in radium therapy for intracorporeal radiation, since the effects of scattering are practically all counteracted by absorption. The values collected in Table III were measured in air without back-scattering. At the present time we cannot present accurate data on back-scattering, but we believe it is probably between 5 and 10 per cent of the direct radiation.

In comparing the results obtained with the number of r-units per erythema dose for roentgen rays, it is found that the number of r-units per erythema dose for the gamma rays of radium is much higher than that of hard roentgen rays, provided that our indirect determination of the r-intensities for gamma rays of radium is accurate. We are now collecting more information on this question by testing these doses of radiation on *Drosophila* eggs, and expect to present a discussion of the physical-intensity values and their biological reaction in the near future.

In order that the physical data may be complete, we wish to add some results which were obtained when measuring with other types of ionization chambers. Two cylindrical chambers of ¼ c.c. and ½ c.c. and a commercial ionization chamber of 6 c.c. were used. The results are presented in Table IV. They have been obtained under the same conditions as those given in Table II.

By comparing the intensities which were obtained with these chambers with those shown in Table II, it may be seen that all ionization chambers, with the exception of the 6 c.c. chamber, gave the same intensities at distances greater than 2 centimeters. The large commercial chamber, however, does not accurately indicate the intensities for distances less than 5 centimeters. All the intensities which were measured with the various ionization chambers are graphically shown in Figure 2. The different chambers and the intensity curves determined with them are designated in the same manner as the data given in Figure 1.

We have also included the intensity measurements made with a radium pack of 4 × 4 cm., using a brass filter of 4 mm. thickness. The intensities of this group at various distances are collected in Table V. This radium pack acts as a point source for distances greater than 4½ cm., beyond which the values of Table II may be used. The results in the third and fourth columns have also been obtained by the same procedures as the values of the corresponding columns in Table III.

CONCLUSIONS

With certain precautions and under certain conditions the r-unit can be satisfac-

torily employed to measure the intensity of the gamma rays of radium. With the gamma rays of radium 2,000 r-units will produce a reaction on the human skin which is usually designated as a skin-unit dose.

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DIAGNOSTIC EXPOSURES IN r-UNITS[1]

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UNDER ordinary circumstances and during uncomplicated examinations the amount of radiation falling on the skin of the patient does not reach clinical importance. This fact is supported by the thousands of examinations which are conducted with a relatively insignificant number of accidents. There are, however, certain circumstances which demand a rather accurate knowledge of the total energy applied.

Difficult or frequently repeated examinations, particularly in obese patients, serial radiography, cinematographic radiography, and examinations performed on patients who are receiving or have received X-ray therapy, all introduce the danger of overexposure.

Erskine (2) as early as 1922 determined the erythema time with diagnostic rays at 10-inch distance and found that at 60 K.V. the minimum E.D. corresponded to 400 ma.-sec. of unfiltered, or 800 ma.-sec. with 1 Al filter. A year later Witherbee and Remer (1), applying their arithmetical method of dosage calculation to the various U. S. Army Manual exposure settings, tabulated the number of plates which might safely be taken.

In 1926 Frik (4) made what appears to be the first move in evaluating radiographic exposures in physical units. He measured the amount of radiation used in fluoroscopy and radiography of both the chest and the gastro-intestinal tract. As a result of his experiments he advocated using greater filtration in gastro-intestinal fluoroscopy and showed that by this procedure the amount of radiation striking the skin during a given fluoroscopic examination might be reduced to one-half or one-third the amount normally used. This reduction in skin dosage was accomplished without impairing the contrast in the fluoroscopic image.

This work of Frik seems to have been the starting point for several articles which appeared in succeeding years, dealing with this subject.

Pohle (3) measured the output of diagnostic machines at 75 and 100 K.V. with 5 ma. and then determined the erythema time of this quality of radiation. He calculated that in gastric examinations with fluoroscopy and the maximum number of films the posterior surface of the body received 60 per cent E.D.

Chantraine and Profitlich (5) studied the output of radiographic and fluoroscopic machines operated at the lower kilovoltages, and derived tables showing the actual amount of radiation received by the skin. They corrected the wave length dependence of their Siemens chamber against a Veifa electroscope. This correction, in addition to the fact that they used soft beams of radiation, accounts for the difference between their results and those obtained by Frik.

Saupe (6), using the Küstner method of measuring, tabulated the average r delivered in certain exposures and calculated 100 r as the safe limit in radiography.

Braun, Hase, and Küstner (7) made still further measurements upon diagnostic beams, and compiled tables of the output of their machines for 1 ma. and voltages ranging from 30 to 100 K.V.P. They further calculated the actual energy required to make various exposures.

In view of the need for readily available data relative to the amount of radiation re-

[1]Read before the Radiological Society of North America at the Fifteenth Annual Meeting, at Toronto, Dec. 2–6, 1929.

quired to make radiograms and the paucity of such data in the English literature, it was decided to measure the output of the available machines and formulate exposure tables.

Six different machines were calibrated over their commonly used range. Four of these were mechanically rectified; in two, rectification was performed by the Coolidge tube. In all cases the measurements were made with the actual milliamperage used in the technic.

A Siemens-Halske dosimeter, using a Glocker chamber and calibrated against a Küstner instrument over the quality region used in radiography, was used to measure the output of the machines. The advantages of short readings and constant uranium control were the principal reasons for using this instrument. The dosimeter was re-checked against the Küstner several times during the course of the experiment and was found constant within the limits of experimental error. Each series of measurements on the radiographic machines were repeated at least twice.

Due to the high intensity produced by some of the technics, measurements were carried out at different distances and corrected to a common distance according to the inverse square law. The error introduced by disregard of air filtration is negligible at the shorter distances and does not amount to more than 5 or 10 per cent at

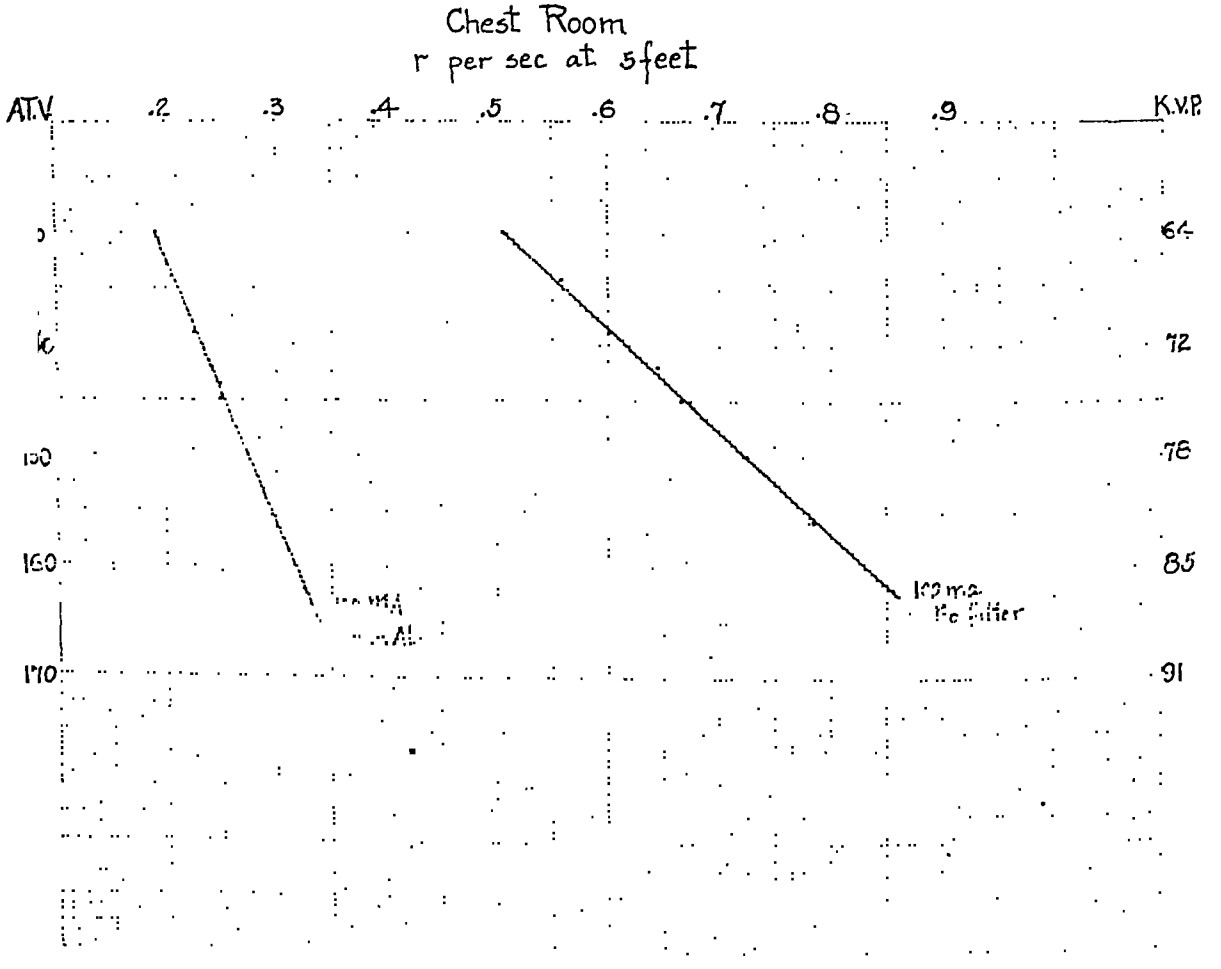


Fig. 1. Typical output chart for a diagnostic machine.

TABLE NO. I-A

EXTREMITY GROUP

Part radiated	Target-to-film distance	r-units at 12 inches F.S.D. Plain films	Screens	Quality range
Fingers	30 inches	½–1	–	50–65 K.V.P.
Hand	"	1–3	1/8–1/2	"
Wrist	"	1–5	1/4–1/2	55–70 K.V.P.
Forearm	"	2–6	–	"
Elbow	"	2–7	1/2–2	"
Humerus	"	2–8	–	"
Shoulder	"	7–12	2–4	"
Foot	"	2–3	–	"
Ankle	"	2–5	1/2–1	60–85 K.V.P.
Leg	"	3–7	–	"
Knee	"	5–9	2–4	"
Femur	30 inches	Plain films 6–12 r		65–80 K.V.P.
Femur	30 inches	Screens and grid 3–10		70–90 K.V.P.
Humerus	30 inches	Screens and grid 1–4		65–90 K.V.P.
Shoulder	30 inches	Screens and grid 2–6		"

All exposures are calculated for one millimeter of aluminum filter unless otherwise indicated.

TABLE NO. I-B

HEAD GROUP

Part radiated	Target-to-film distance	r-units at 12 inches F.S.D. Screens	Screens and grid	Quality range
Jaw	25 inches	1/2–2 (with plain films 4–6)		75–85 K.V.P.
Skull:				
Lateral	25 inches	–	5.6–6.5	80–95 K.V.P.
A. P.	25 inches	–	7–12	"
Mastoid	Cone	3–5	–	"
Sinuses:	Contact cone F.S.D. to scalp			
Lat. frontal	14 inches	1–3	2–4	85–100 K.V.P.
Granger	14 inches	3–5	8–10	"
Caldwell	14 inches	3–5	9–12	"
Waters	14 inches	5–8	9–12	"
Vertico-mental	14 inches	7–9.5	12–14	"
Lateral sella	14 inches	3–5	–	"

longer distances for the softest radiation used.[2]

Graphs were then prepared for each of the machines, showing the energy output of the technics in common use on the particular machine in question. Figure 1 shows two such graphs. It may be seen that with fixed milliamperage, the output is practically a linear function of the voltage as long as the same Coolidge tube is used. From these charts the energy output in any of the technics used may be calculated.

The minimum and maximum amounts of radiation delivered in making films of various parts of the body are presented in No. 1. These extremes range from the lightest to the heaviest specific part encountered. It will be noticed that the intensities are recorded at one of two distances, 12 or 60 inches F.S.D., and must therefore be corrected by both distance and back-scattering factors before the actual amount on the patient is known. In applying the first correction the target-to-skin distance must, of course, be known or estimated.

The second correction is calculated pre-

[2]The air filtration values for monochromatic radiation, as tabulated by Odencrantz (8), are not strictly applicable to a heterogeneous beam. However, by determining the absorption in one or two millimeters of aluminum we may place a value on the softer, and hence more readily air-absorbed, portion of the beam. The diagnostic range measured in this manner gives an effective wave length of around 0.5 A.U. with one millimeter of Al, and 0.45 with two millimeters of Al. The half value layer in Al ranges from one to one and one-half millimeters, when a filter is used in the tube stand, and between one-half and one millimeter when no filter is used.

TABLE NO. I-C

THORAX GROUP

Part radiated	Target-to-film distance	r-units at 12 inches	Quality range
Ribs	30 inches	Screens and grid 1-4.5	65-85 K.V.P.
Chest	40 inches	Screens 1/4-2/3	60-80 K.V.P.
		r-units at 5 feet Screens	
Chests P. A.	7 feet	0.08-0.4	60-85 K.V.P.
Lateral	10 feet	1/2-3	65-90 K.V.P.

TABLE NO. I-D

ABDOMEN

Part radiated	Target-to-film distance	r-units at 12 inches Screens	Screens and grid	Quality range
	Contact cone			
Gall bladders	18" F.S.D.		2-11	60-80 K.V.P.
Gastric (Opaque Meal)	30 inches	3-10		90-110 K.V.P.
Enemata (Barium)	36 inches	3-10		70-95 K.V.P.
Kidneys	30 inches		5-18	60-85 K.V.P.

SPINE AND PELVIS

Part radiated	Target-to-film distance	r-units at 12 inches Screens	Screens and grid	Quality range
Cervical spine:				
A. P.	30 inches		2.5-6	70-80 K.V.P.
Lateral	8 feet	½-1 r (at 5 ft.)		
Dorsal spine:				
A. P.	30 inches		3-20	75-95 K.V.P.
Lateral	30 "		6-32	80-100 K.V.P.
Lumbar spine:				
A. P.	30 inches		5-30	75-95 K.V.P.
Lateral	30 "		10-60	80-110 K.V.P.
Pelvis:				
A. P.	30 inches		2.5-16	75-95 K.V.P.

cisely only with some difficulty. The many changing factors—quality, field size, and part radiated—tend to introduce shifting errors of a magnitude which renders any attempt at more than an approximation illusory.

Based on water phantom measurements we estimated the amount of back-scattering in diagnostic radiation to be between 15 and 25 per cent. Back-scattering correction may be avoided entirely by regarding it as practically constant throughout the diagnostic range. This simplifies the calculation and allows the estimation of the total amount of energy administered in terms of percentage of the "air value."[3] (9) With Table I and a knowledge of the target-to-skin distance the amount of energy in terms of "air value" which falls upon the skin may be calculated.

This brings us to a subject of vital importance to radiologists, namely, the amou of radiation which may safely be used diagnostic exposures.

Frik (4) based his limit exposure dete mination on 700 r (air).

Saupe (6) and Braun, Hase, and Küstne (7) believe 100 r the upper limit of safety, while Chantraine and Profitlich (5) use 300 r as the basis for some of their fluoroscopic calculations.

Our experience leads us to endorse the limit set by Saupe, namely, 100 r. One hundred fifty r (measured in air) of the quality commonly used in diagnosis will produce pigmentation in an appreciable number of

[3] As will be seen later, under the discussion of quality and film latitude effects, the influence of back-scattering on the total amount received by the skin becomes insignificant by comparison.

cases, while an approach to 300 r begins to enter the epilating range. Very occasionally we see pigmentation following the administration of 100 r.

The safe limit in diagnosis, then, would appear to be about one-third of the "toleration dose," or 100 r, and while the range between 100 and 200 r is fairly safe, it should be entered only when necessity demands.

It is important to bear in mind that three major factors aside from biologic differences cause variations in the amount of radiation falling on the skin in making radiograms: the quality of the radiation, the latitude of the film, and the nature of the equipment in use.

The softer beams of radiation, used to increase contrast, require much larger amounts of energy incident on the skin to produce radiograms than do the more penetrating beams. It becomes apparent from this that the safest beam for any particular part is that which gives the greatest penetration compatible with satisfactory contrast.

As will be seen in Table I, we have expressed quality in terms of kilovolts (measured with a sphere gap). We realize that, strictly speaking, this method is somewhat inaccurate. The wall thickness of the tube, the thickness of the protective filter, as well as the type of rectification, all introduce variations in quality which a sphere gap measurement would not detect. On the other hand, sphere gap measurements have in the main been entirely satisfactory for transferring radiographic technic. It is for this reason that gap measurements are used to express quality.

The second factor introducing major variations in the amount of radiation used in taking radiograms is film latitude. This varies somewhat depending on the density of the part to be demonstrated and on whether screens are or are not used. However, it usually amounts to 50 per cent or more on either side of the average. This means that films of diagnostic value may be made with 50 or 150 per cent of the optimum 100 per cent energy for that part. In many instances the variation is even greater.

TABLE II

Part radiated	Amount on skin (r)	Number of films totalling 100 r
Hand	0.5	200
Forearm	1.2	80
Elbow	1.3	75
Humerus	1.7	60
Shoulder	3	30
	1.8*	55
Knee	2.5	40
	1.5*	65
Femur	1.0*	25
Chest (A. P.	0.3†	330
Chest (Lat.	0.8†	120
Jaw	2.5	40
	0.8†	120
Skull (Lat.	4.5*	20
Skull (A. P.	12*	9
Sinus:		
Lat. Frontal	2.5†	40
Granger	4.5†	22
Caldwell	1.5†	22
Waters	7†	14
Vertico-mental	9.5†	10
Cervical spine	2.5*	40

*With screens and grid
†With screens

Examples of this wide latitude may be seen particularly in the radiography of small parts on plain films. Satisfactory radiograms of the hand may be made over a variation range of 300 per cent.

The third factor influencing the radiographic energy requirements has to deal with the efficiency of screens and grids, as well as the filtering action exercised by various interposed pieces of equipment, such as table tops. It will be seen from a consideration of these factors that the safest table to use as a limit in any laboratory is one which represents the highest values met in that laboratory. This thought has been followed in preparing Table II, and 100 r is used as the safety limit in figuring the number of films allowable.

In Table III an attempt has been made to demonstrate the manner in which radia-

TABLE III

(1 MM. AL FILTER THROUGHOUT)

Part	Thickness in centimeters	K.V.P.	ma.	Target-to-film distance cm.	Time (secs.)	r per exposure calculated on skin	No. of films totalling 100 r
Dorsal spine A. P.*	15	76	20	75	4½	1.4	70
	17	80	20	75	5½	2.1	46
	20	84	20	75	7½	3.6	28
	24	87	20	75	10½	7.2	14
	28	92	20	75	12	9	10
Lateral*	18	78	20	75	5½	2.	50
	20	80	20	75	5½	2.5	40
	24	84	20	75	8	4.7	20
	30	90	20	75	11	10	10
	34	99	20	75	18	22	4
Pelvis*	15	78	20	75	3½	1.5	65
	20	82	20	75	7¾	4.	25
	25	86	20	75	10½	8.	12
Lateral lumbar*	23	85	20	75	10	7.7	13
	26	92	20	75	13½	10.5	9
	30	100	20	75	19½	21.5	4
	36	100	20	75	28	47.	2
Gastric region†	16	95	60	80	½	1.4	70
	20	98	60	80	½	2.2	45
	24	100	60	80	½	2.6	38
	30	105	60	80	½	4.	25

*With screens and grid.
†With screens.

tion requirements change with increasing thickness of the part.

It must be understood that the values in all of these tables hold exactly only with the technic for which they were compiled. Our required radiation values agree within expected limits with those published by the previously mentioned German workers. On the other hand, the amounts of radiation administered in other laboratories might reasonably be expected to vary as much as 100 per cent from the values presented here. Those workers using lower voltage, blacker films, or less efficient accessories might exceed these values, and, consequently, have a lower limit of safety.

Those radiologists adhering to a fairly penetrating technic and using efficient equipment will find that these values are somewhat high. This is particularly so when our higher values, designed for heavy patients, are applied to patients of average size. An example of this fact may be seen in a consideration of the radiation requirements in chest radiography. With double screens and good penetration, satisfactory films are obtained in the average patient with 1/12 to 1/10 r incident on the skin.

It becomes evident that those roentgenologists using or planning to use multiple exposure technics should depend on the individual calibration of their machines and measurements of their patients.

The addition of fluoroscopic to radiographic examinations naturally decreases the number of films which may safely be taken. The output from fluoroscopic sets varies quite a bit, and calculation of safety limits on the basis of milliampere-minutes is not without risk. Indeed, it is far safer to actually test the erythema time on small skin areas, if calibration is not available.

Chest fluoroscopy at the University Hospital is performed with an intensity of between 10 and 15 r per minute, whereas gastro-intestinal work may require up to 20 r per minute incident on the skin.

SUMMARY

Six diagnostic X-ray machines were calibrated over their commonly used range. Calibration charts were prepared which enabled the accurate calculation of the amount of energy used in diagnostic exposures.

From these charts and exposure tables based on thousands of satisfactory radiograms, the largest and smallest amounts of radiation used for certain parts were determined.

Safety tables based on the energy required for the heaviest part likely to be met with were prepared. Further tables were prepared illustrating the increase in energy with increasing thickness of the part.

The influences of quality of radiation, type of equipment, and film latitude on the total radiation applied are noted and the advisability of using the greatest penetration compatible with adequate contrast stressed.

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(9) Hickey, P. M., Pohle, E. A., Lindsay, G. A., and Barnes, J. M.: Radiology, April, 1929, XII, 309.

DISCUSSION

Dr. Arthur W. Erskine (Cedar Rapids, Iowa): The striking point brought out by the essayist in this presentation is that, with proper radiographic technic, the quantity of X-rays as measured on the skin in absolute units is surprisingly small, and consequently a large number of films can be made in safety. Dr. Pohle, at the University of Wisconsin, independently from this work, made some investigations, and he has allowed me to present a slide which gives the average results of some of his measurements. The last column shows the average number of r-units on the skin and they agree rather well with the observation of Barnes and Meltzer. For instance, Dr. Pohle observed that the skin received 6.4 r for an average antero-posterior skull, while the essayists report, with various technics, a range of from 3 to 9.5 r; so we can say that the two observers agree within 50 per cent, at least.

It must not be assumed that the number of films as shown in the tables mentioned by the essayists can be safely made with a poor technic or with an uncalibrated technic. We know, of course, that with poor technic the exposures are sometimes many times larger than necessary. I would suggest, as the essayists did, that those who routinely make many films of single patients, and especially those who make cinematographic exposures, should have their diagnostic apparatus calibrated.

Dr. Barnes (closing): I wish to thank Dr. Erskine for his discussion of the paper. One might bring out the possibility of taking a leaf from the book of Fricke, who introduced greater filtration in fluoroscopy of the gastro-intestinal tract. With 100 K.V. peak, a moderately large field and one millimeter of aluminum filter, phantom measurements will show that about four and a half or five centimeters of water will absorb 50 per cent of the energy striking the surface. That would mean, then, that we are putting on the skin, during exposures of heavy parts, radiation which does not get

through and affect the photographic film. It would seem that increasing filtration, particularly in radiography of heavy parts, might be worth while.

Can Radiology be a Science? A. E. Barclay. Brit. Jour. Radiol., November, 1929, II, 509.

This paper, presented before the Society of Radiographers of England, emphasizes the need of always looking upon the practice of medicine, including the practice of radiology, as an art rather than as a pure science, since one must always consider the patient's complex or psychology in evaluating not only the symptoms complained of but the signs elicited during the roentgenologic study. A brief outline of the progress of radiology since its inception and the days of the first gas tubes, when an X-ray tube was a "glass globe surrounded by a zone of profanity," is given, but while its development as a science has gone far, the patient's individual peculiarities, susceptibilities, and idiosyncrasies will always make the final evaluation of the radiologic findings something of an art. The paper closes with an apt quotation from Dr. Oliver Wendell Holmes: "Science is a first-rate piece of furniture for a man's upper chamber, if he has common sense on the ground floor."

J. E. HABBE, M.D.

THE QUARTZ MERCURY ARC[1]

By WILLIAM T. ANDERSON, JR., PH.D., NEWARK, NEW JERSEY

WHEN two carbons are attached to an electrical supply of 100 volts direct current and are made to approach each other, nothing happens until the distance between them is less than that of a very thin sheet of paper. Ordinary air is a very excellent non-conductor.

If the carbons be touched together, the current begins to flow and an enormous amount of heat and a temperature of approximately 3,500° C. is generated at the point of contact, for it is at this point that most of the resistance of the circuit is located. If the carbons are now separated slightly, *e.g.*, half an inch, and if the air between the carbons were in the same condition as before, the flow of current would cease immediately; but the air between the carbons is not in the same condition. The entire region is filled with ionized gases and has now become a good conductor. The reason for the changed condition lies in the property of white-hot bodies to give off positive and negative ions and electrons in huge quantities. These ions carry the electric current. The negatively charged electrons given off at the cathode (negative electrode) bombard the anode, producing an intensely hot spot called the "crater."

Most of the light from the pure solid carbon arc comes from this positive crater, *i.e.*, it is pure temperature radiation produced as a result of the high temperature of the crater. The ionized vapors produce very little light, that which they do emit being largely confined to the so-called "cyanogen" band located in the long ultra-violet and violet portions of the spectrum. It is not surprising that the pure carbon arc emits practically no radiations corresponding to the short ultra-violet of sunlight, for the glowing carbons do not attain a sufficiently high temperature to emit the short wave lengths of radiation which the sun, at a temperature of 6,000° C., can produce.

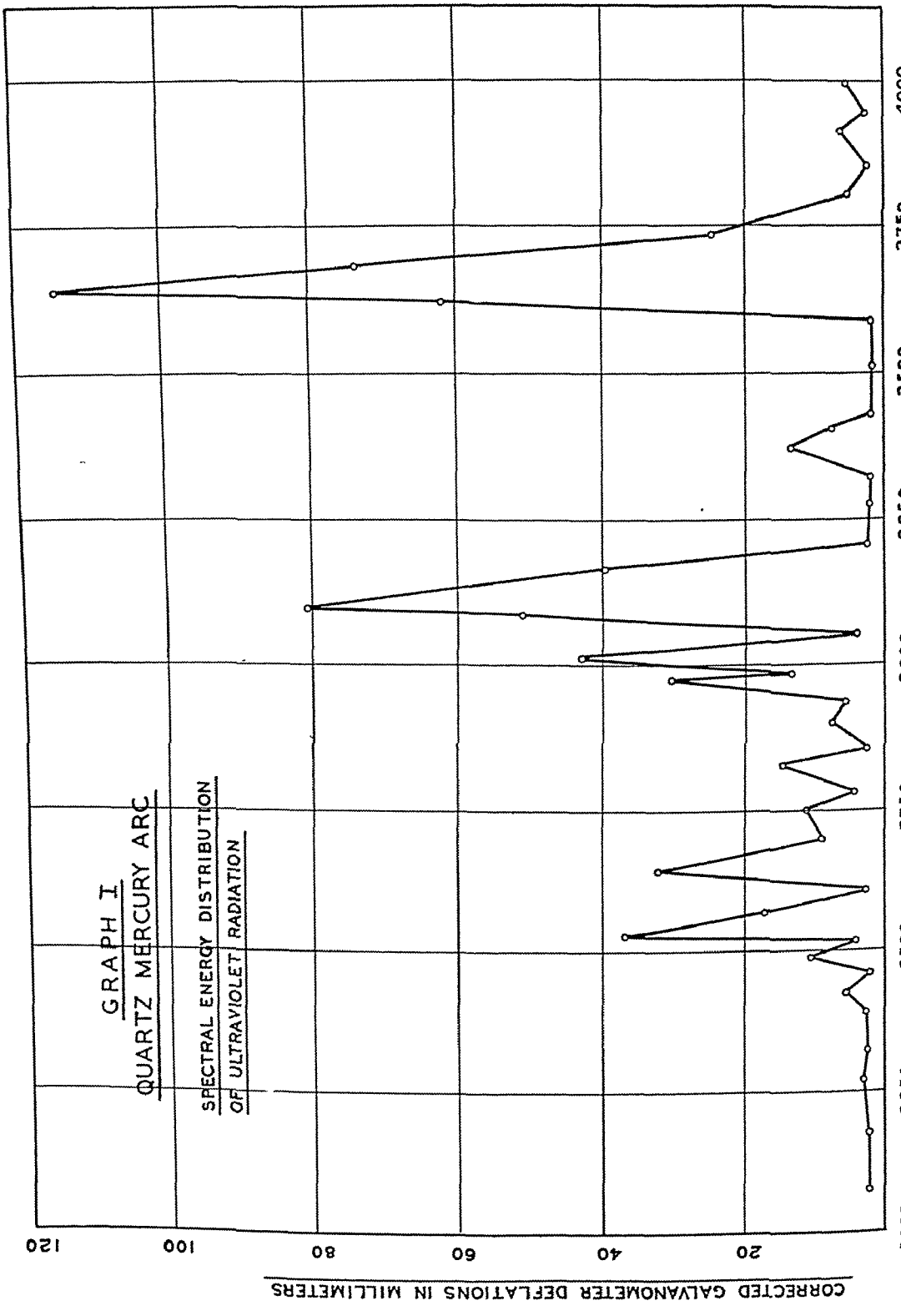
Impregnation of the carbons with salts or metals produces the flame arc which is characterized by greatly increased light production in the ionized vapors and lowered temperatures, and therefore lowered light production, at the positive crater. Such an arc is vastly more efficient as a producer of light, for more of the energy is converted into light, and less into heat, than in the pure carbon arc. The kind of light emitted and the efficiency are dependent on the chemical nature of the impregnating materials.

It can be understood that as the electrode temperatures decrease, and more and more of the electrical energy is consumed in the ionized vapors, the efficiency and light production increase rapidly.

The electric arc reaches its peak of attainment in the vacuum quartz mercury arc. Here the electrodes are two pools of mercury maintained at a temperature between only 300 to 400° C., *i.e.*, comparatively cool. These give off some low temperature infra-red and heat, but no visible or ultra-violet light. The visible and ultra-violet radiations are all emitted by the ionized mercury vapor, a condition which permits attainment of the highest arc efficiency.

The natural efficiency of the quartz mercury arc in converting electrical energy into ultra-violet light is enhanced by a predominance of ultra-violet in the light emitted by ionized mercury. Considering the range of light wave lengths transmitted by the quartz, namely, from 1,850 Å.U. in the short ultra-violet to 40,000 Å.U. in the long infra-red, 28 per cent of the emitted energy

[1]Read before the Radiological Society of North America, at Chicago, Dec. 3–7, 1928.



Graph I. Quartz mercury arc. Spectral energy distribution of ultra-violet radiation.

is in the ultra-violet, an amount greater than that obtainable by any other arc or light source.

The quartz mercury arc is not a cold source of light, deficient in infra-red rays: 52 per cent of its radiation is in the infra-red, a proportion which compares favorably with that of the sun itself, which has 60 per

cent infra-red. It is only by comparison with the solid core non-impregnated carbon arc and the tungsten incandescent lamp, which produce 95 per cent of their radiation in the infra-red, that the conception of the quartz mercury arc as a cold source can be justified.

The quartz mercury arc is low in visible light as compared to the sun, the percentage ratio being about 20 to 33. The luminous efficiency of the quartz mercury arc is about 5 candle power per watt of input as compared to 3 candle power per watt for the impregnated flame carbon arc, and 1 candle power per watt for the solid core non-impregnated carbon arc. The quartz mercury arc is, therefore, a very efficient source of visible light.

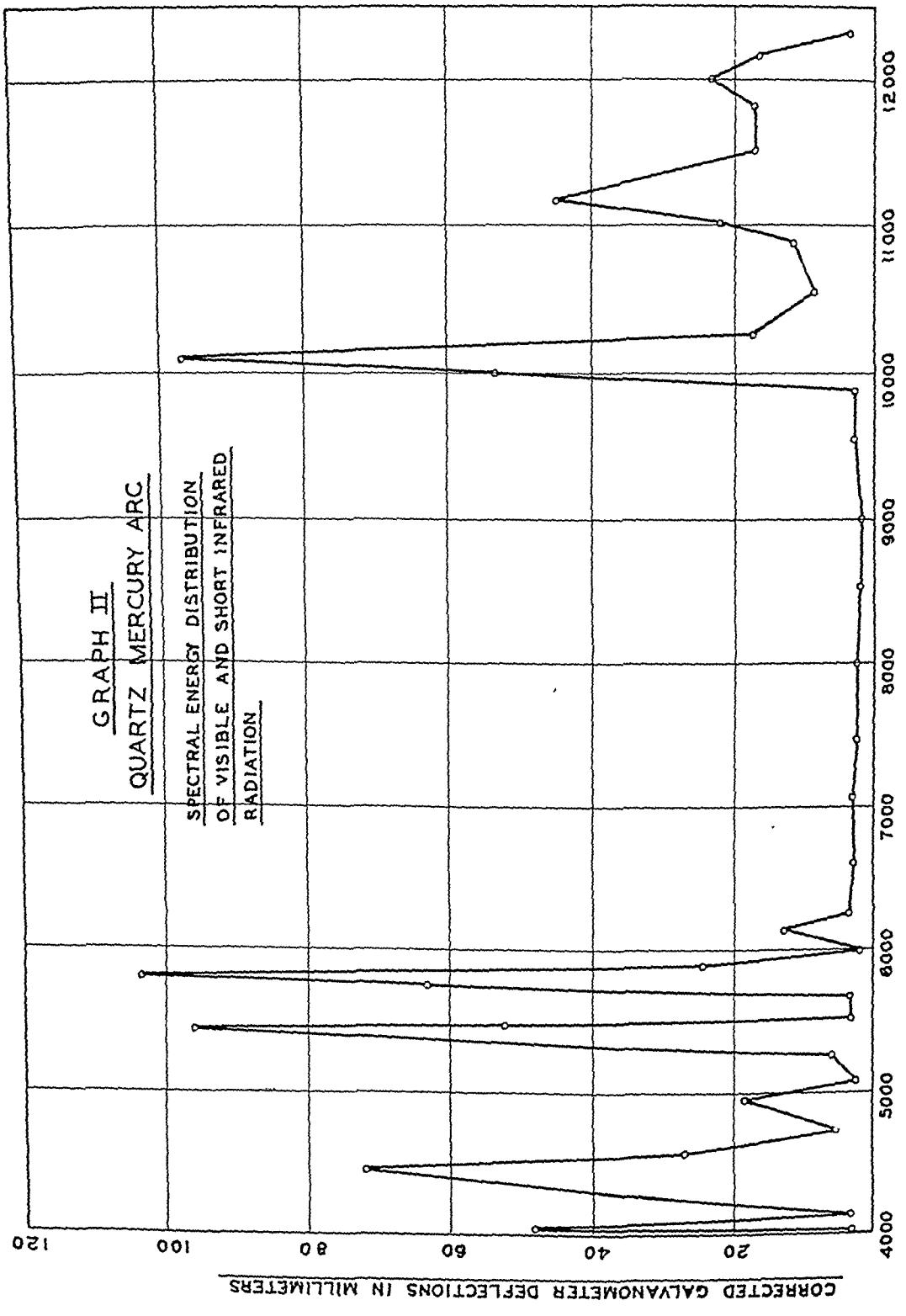
It is important to consider not only the apportionment of energy between the different parts of the spectrum such as the ultra-violet, visible, and infra-red, but also the wave lengths available in each portion, *i.e.*, the spectrum, and the quantity present at each wave length.

All the arcs, including the quartz mercury arc, produce a continuous spectrum, *i.e.*, the light from them consists of every wave length from the very short ultra-violet to the long infra-red. However, not all wave lengths have equal amounts of energy: some wave lengths may possess many times the energy of their neighbors. Since the action of a wave length of light on a photographic plate is dependent largely on the intensity, a very short exposure records photographically only the more intense bands of wave lengths. Exposures of increasing duration record more and more of the wave lengths, until finally a time is attained when all wave lengths have affected the plate sufficiently to show the characteristic unbroken continuous spectrum.

In trained hands and with special precautions, a modification of the preceding may serve as a relative measure of the energy in various wave lengths of the spectrum. However, the ordinary spectrogram which is made without any regard to time of exposure and plate sensitivity indicates solely the wave lengths of light available and tells nothing of the light energy at each wave length. It is advisable not to judge a light source on its spectrum alone, for on this basis the ideal ultra-violet source would be the automobile spark plug operated on the automobile ignition system, which produces a better spectrogram than can be obtained by the quartz mercury arc or any of the carbon arcs.

The quantity of light energy available at each wave length is very important, and this the spectrograph ordinarily does not show. This must be determined by the physicist who either employs special photographic methods or by special apparatus separates the wave lengths and measures the energy in each. When this is done, it is found that the light from the quartz mercury arc comprises every wave length from the short ultra-violet to the long infra-red, *i.e.*, a continuous spectrum which has a low intensity and a number of groups of wave lengths, known as bands, which have exceedingly high intensity. The mercury arc is exceptionally rich in intense bands in that region of the ultra-violet spectrum corresponding to the short ultra-violet of sunlight. However, it must not be inferred from this statement that the energy distribution of the quartz mercury arc resembles that of sunlight. It does not. Neither does the carbon arc, nor any other light source dependent on ionization.

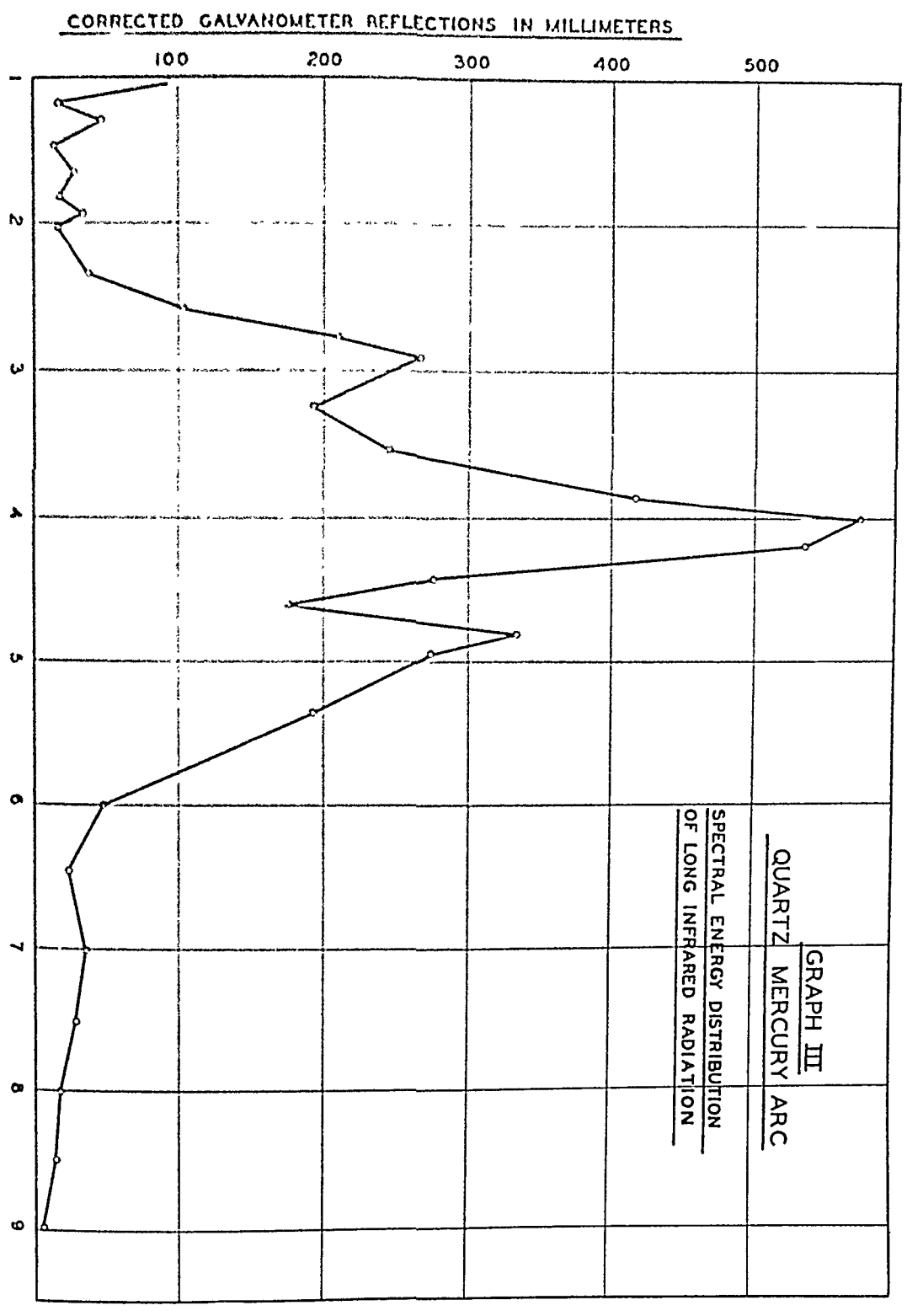
Because of the high efficiency and predominance of ultra-violet in its spectrum, the quartz mercury arc produces an intensity of ultra-violet radiation which can be equalled by other artificial light sources only by the expenditure of four or more times the electrical energy. With regard to power consumption, the quartz mercury arc



Graph II. Quartz mercury arc. Spectral energy distribution of visible and short infra-red radiation.

is the most economical artificial light source known.

In practice, the mercury arc must be enclosed in an evacuated envelope of quartz which can transmit the ultra-violet radiations and can withstand the temperature changes to which it must submit. Glass, even though it transmitted the ultra-violet, could not withstand the temperatures encountered in the arc tube. Thus fused



Graph III. Quartz mercury arc. Spectral energy distribution of long infra-red radiation.

quartz serves in a dual rôle, and is indispensable to the existence of the arc.

Quartz mercury arcs slowly deteriorate with use, though the deterioration does not affect the spectrum of the lamp. An old burner which has not been improperly cleaned and is not blackened because of a poor vacuum gives the same spectrum as a

the material of which the anode is composed. This may also deposit upon the window, adding to the filtering action of the tungsten. It seems probable that the evaporation of tungsten is the most important source of filtering material.

Treatment with the Grenz ray was instituted in this Clinic December 20, 1928. A table of the intensities to be expected at various skin target distances was furnished with the apparatus. These intensities were measured abroad by means of the Küstner apparatus and were given in r-units. After the first tube had been in continuous service for over a year, during which time 260 treatments aggregating 31.38 hours were given with it, the intensity of its radiation was measured. A standard air ionization chamber of the Duane type was used, with a galvanometer to measure the current.

The values found were approximately only 60 per cent of what the tube was supposed to deliver when it arrived. It was apparent that either the method of measurement was at fault, or else the window had become contaminated. In order to determine what had happened, a spare tube that had never been used was installed, and the intensity measurement repeated. It was found that the intensity given by this tube checked within experimental error with the values determined abroad by means of the Küstner apparatus.

More complete measurements were then made with each tube, and are presented graphically in Figure 1. The tubes were both operated at 10 ma. and 9 kilovolts. Successive filters of celluloid, each 1/100 inch in thickness, were interposed in the beams, and the "absorption curves" determined. These curves show that the old tube is now capable of delivering only 57.5 per cent as intense a beam as the new tube. The quality has changed also, as it requires .012 in. of celluloid to reduce the beam from the old tube to half value, whereas it requires only .01 in. to reduce the beam from the new tube in the same proportion. The action of the contaminating material upon the window is, therefore, to reduce the intensity at the expense of the softer, less penetrating part of the radiations. If we make the assumption that the deposition of foreign material on the window of this tube was proportional to the time it was in operation, we can calculate that for every hour of use, the intensity decreased by approximately 1.3 per cent of its original value. This is, of course, only an approximation, and measurements must be made with many tubes before any very general statement can be made. It will, however, serve as a guide in the transfer of dosage when it becomes necessary to change tubes, and may help to explain some of the variations in results that have been reported by different operators using this same type of tube, and apparently employing the same technic.

THE LONG SPACINGS OF RUBBER AND CELLULOSE

By GEORGE L. CLARK, Ph.D., and KENNETH E. CORRIGAN, M.S.
From the Department of Chemistry of the University of Illinois

THE purpose of this investigation was to find a means of attack on the analysis of those compounds some of whose crystal diffraction spacings lie between the ranges of X-rays and the ultraviolet region. In this group the most important at present are rubber and cellulose, although many other uses such as the study of proteins and tissues might be found for such a method.

These compounds in their natural state are made up of aggregates of small units. When examined by the X-ray method, they for the most part give only a diffuse band that is termed an amorphous ring. When stretched or strained (in the case of rubber) or lined up along the fiber axis (in the case of cellulose), these same compounds give a more or less complete fiber pattern, showing that the amorphous ring in reality conceals a true crystalline structure. This crystal structure, as will be shown, has been a continuous source of controversy. Various formulæ for rubber have been proposed, proved, and disproved; cellulose has fared the same way. In each case the parent chemical substance is well known, but what number of units make up the ultimate particle, that is, at what point C_5H_8 ceases to be isoprene and becomes rubber, can not be shown until the unit cell has been definitely measured.

For some time rubber was considered to be entirely amorphous. In 1924 and 1925, however, a number of papers appeared by Clark,[1] Katz,[2] and Hauser and Mark,[3] which indicated a different condition. All agreed that vulcanized rubber gave only the broad amorphous ring; in certain cases raw unstretched rubber was reported as giving interference rings indicative of crystalline structure.

While this work was in progress Plummerer and Koch[4] tried successfully to isolate crystalline material by repeated extraction of raw smoked sheets and purification of the product. They reported the finding of colorless, non-elastic crystals, and, further, an analysis of these crystals. The unit cell dimensions were $4.83 \times 4.71 \times 5.33$, the form monoclinic, the angle between the axes 77° 19′, and one molecule in the unit cell. This work has not been repeated.

Several investigators, Katz in particular, have tried to crystallize rubber by cooling it to low temperatures. This seems to be unsuccessful in the case of raw unstretched rubber. In the case of the stretched rubber it is generally reported that the crystal pattern formed by the stretching is fixed, and remains after the material has returned to normal temperature.

The examination of stretched rubber gives by far the most important information. The photograph of this shows sharply defined maxima indicative of a fiber diagram superimposed on the amorphous ring. This demonstrates that the crystalline material is not in random orientation, but has assumed the form of long fibers containing all of the crystalline material and oriented along the axis of elongation. Calculations show that the isoprene unit is the basis of the crystalline material. Vulcanized rubber gives the same effect, but the required amount of elongation is greater than in the case of the raw rubber.

[1] Am. Jour. Roentgenol. and Rad. Ther., December, 1924, XII, 556.

[2] Chem. Zeit., April 25, 1925, XLIX, 353. Die Naturwissenschaften, May 8, 1925, XIII, 410. Ztschr. angew. Chem., 1925, XXXVIII, 439. Kolloid-Ztschr., 1925, XXXVI, 300; 1925, XXXVII, 19.

[3] Kautschuk, December, 1925, p. 10. Kolloidchem. Beihefte, 1926, XXII, 63.

[4] Justus Liebigs Ann. d. Chem., 1924, CDXXXVIII, 294.

In the course of their investigation Hauser and Mark accustomed their eyes to the dark by remaining in a darkened room for five hours and then watched the process of orientation by means of a fluoroscope while the sample was being stretched. They found that the interference maxima appeared instantaneously, but that they remained for some time, in certain cases as long as one hour, after the tension had been released.

The primary interest of all the investigators was to find the unit cell of rubber. Katz, as well as Hauser and Mark, calculated unit cells which were rhombic in form from the Hull-Debye-Scherrer rings by use of the Polanyi equation. Katz obtained $8 \times 6.5 \times 6.5$ Å., while Hauser and Mark measured $8.0 \times 8.6 \times 7.68$ Å., the correct dimensions. This would indicate four molecules of isoprene per unit cell, or more, if the spacings are of the second order. Ott[5] examined a specimen of crepe rubber and found the greatest spacing, $d = 6.37$. From the calculated volume of the molecule of isoprene, he decided the unit cell contained six isoprene units. His assumptions in this calculation were attacked by Herzog.

The present status of knowledge of the structure of cellulose has been so thoroughly and excellently covered in recent papers[6, 7] that it will not be discussed in the present paper. The latest investigations by Mark and Meyer[8] show that the unit cell is monoclinic with the following definite dimensions: $8.3 \times 10.3 \times 7.9$ Å., $\beta = 84°$.

THEORETICAL

From all the mass of information on these polymerized compounds, rubber in particular, several important theories have grown up. In the first place, it was shown that the line breadth of the diffraction pattern did not change with stretching, and therefore that the effective particle size remained the same. From the Debye-Scherrer equation, Clark estimates this particle to contain two thousand molecules of isoprene.

In the usual case a unit cell can not contain less than one molecule of any substance, but it is apparent at once that the cells which have been measured in this case can contain only a small fraction of a long and exceedingly complex chain.

From the fact that the crystals observed upon stretching a sample appear at once, it is obvious that those crystals existed in some other form in the sample before stretching. The theory advanced by several writers is that, upon stretching, the angles between groups in the molecule, the chain being a spiral, are changed, and that in the course of this changing certain groups are brought into such relation with each other that they form continuous planes which diffract X-rays. If this theory is correct, then these planes in reality may have almost nothing to do with the true structure and properties of rubber, a case which is not true. A single point in its favor is the fact that although these planes appear instantly they take some time to disappear. Their appearance would depend only upon the mechanical pull necessary to bring these groups into the proper position, while their disappearance would depend upon the action of comparatively weak secondary valence forces to bring them back.

It becomes apparent, however, that if the true unit cell is to be measured, then stretching must not be employed except as a last resort, and any data so obtained must be interpreted with caution. On the other hand, if a means is perfected to take these measurements in their normal state, there is no question of mechanical interference of this sort.

There are several theories which attempt

5 Die Naturwissenschaften, 1926, XV, 320.

6 Bragg, W. H.: Cellulose, April, 1930, I, 80.

7 Clark, G. L.: Ind. and Eng. Chem., May, 1930, XXII, 474.

8 Ber. Dtsch. Chem. Ges., 1928, LXI, 593. Ztschr. f. Phys.-Chem., Abt. B2, 1929, p. 115.

to explain the state of molecular aggregation in the amorphous condition. The most logical, advanced by Clark, is that in this case the molecules are in the condition of a regular crystal, i.e., benzoic acid, which has been heated up just below its melting point. In this case a normally crystalline material retains its crystal faces, but when examined by the X-ray method shows no internal crystal structure. It would seem, however, that if this theory were correct, freezing the amorphous material, particularly while it was being agitated in some way to give it a chance to crystallize, should cause it to change over to a definite crystal form. This does not appear to be the case.

A second assumption is that in the original form it is possible that the material exists as preformed aggregates, but since the aggregates are so large the planes are too far apart to enable interference of the rays ordinarily used. The spacing, whatever its nature, is certainly larger than the wave length of the ray, and the limits of interference are unknown. There is almost no firm basis for this theory, but it is the one which the authors hope to prove or to disprove in some definite way.

In the case of cellulose the conditions are somewhat different, since this cannot be considered amorphous. The crystal grains or colloidal micelles have been shown definitely to consist of bundles of long primary valence chains of glucose residues arranged in unit monoclinic cells, with each chain a spiral which has a definite periodic arrangement of the hexagonal rings.

The spacings already found by the X-ray method for cellulose fibers have a long period of 10.3 Å., and, as shown elsewhere in this paper, a monoclinic unit cell can be calculated. Clark has pointed out that this cell contains four glucose residues, arranged in spirals at the corners and along the longitudinal axis. It now becomes obvious that, considering the great molecular weights which have already been determined for cellulose, this unit does not embody the length of a whole macro-molecule but simply of a definitely recurring period in the micelle. Since the copper radiation cannot be used to measure much longer spacings, the next step is to apply a longer wave length in order to measure a period which may represent the dimensions of the macro-molecule or the micelle.

Since the characteristic radiation of each element increases in length with decrease in atomic number, the use of various target materials below copper in the periodic table would give the desired wave length. The elements which suggest themselves are iron, aluminum, magnesium, carbon, and beryllium. Since the K alpha line for magnesium is at 9.86 Å. (Siegbahn), and this material is readily obtainable in pure form, it was chosen for use in the present investigation.

Since this radiation is easily absorbed by air, some form of vacuum spectrograph was necessary. Such instruments have been designed for work on emission spectra with a very thin window through which the rays from the X-ray tube could enter. It occurred to one of the authors that an instrument might be constructed in which there was no obstruction between the source of the X-rays and the recording film since the two were contained in a single evacuated container. Such an instrument was built and is described in detail.

EXPERIMENTAL

1. *Apparatus.* Two vacuum spectrographs have been constructed. The first consisted of a box of 8.5 cm. square cross-section, 30 cm. in length, inside measurement. One end was permanently closed and the other open. The open end was reinforced all the way around with quarter-inch square brass rod to which the plate which

make it possible to obtain pictures in a shorter time and hence with less fogging of the film.

2. *Method of Operation and Results.*—Several attempts were made to run the first tube, using a magnesium target. In general, these first attempts were not successful. The primary trouble with the tube was the fact that the flat sides offered too much area to the pressure of the atmosphere and were crushed to the point where some of the soldered seams started to leak. This was overcome by soldering strips of one inch channel iron at about one inch intervals over the surface. Shortly thereafter a successful run was made, using a magnesium target and a tiny chip of calcite for a specimen. A partial Laue pattern was obtained, which proved the presence of the wanted ray.

In order to check the tube a copper target was made and inserted. By replacing the camera and end plate with a plate of aluminum the beam could be observed with the fluoroscope and properly focussed so that a powerful ray was obtained. A carbon target was turned out of high grade graphite and tried once. This work will be carried farther in the future.

The investigation of rubber was then started. All of the samples were thin vulcanized sheets about 0.1 mm. in thickness. Using a magnesium target and operating at 10–20 P.K.V. with a current of 15 ma., patterns were obtained for pure vulcanized rubber without stretching. The time required was ten hours and the distance from specimen to film was exactly 15 centimeters. Although this method fogs the film badly, a sharp intense ring with a diameter of 31 mm. was seen on the film. This beyond doubt indicates the most important spacing within the range of this tube. Several spots appeared which seemed to be intensity maxima, but as yet no information has been obtained from them. The fogging prevented any weaker lines from showing up.

The second tube was used in the work on cellulose and its operation was found to be very simple and satisfactory. A high vacuum was obtained in about one and one-half hours. The pressure was then allowed to rise to the point where the tube would pass sufficient current, and after the preliminary "gassing out" it was found that the current could be held very steady for a long time. In taking the diffraction pattern of ramie, described below, the tube was operated constantly for thirty hours.

For the examination of ramie a very small bundle of fibers, all arranged parallel, was fastened to the pinhole. The fixed film-holder was placed in the extreme rear of the camera at a distance of 17.3 centimeters. The movable holder with the hole in the center was fitted with a film from the center of which a small circle had been cut with a cork borer. This film was set 4.7 cm. from the sample. Three important rings were found on the two plates, and the rear plate had a partial ellipse outside of the other markings. Their diameters were measured as follows: front film, one ring, diameter 11 mm.; rear film, two rings, diameters 12.5 and 20.5 mm.; ellipse, diameter 22 millimeters. The ellipse was about one millimeter in breadth and was measured between the points of half intensity.

3. *Interpretation and Calculation of Results (A. Rubber).*—The diameter of the sharp ring was found to be 31 mm., which gives a value for d of 99.25 Å. Dividing the cube of this spacing by the calculated volume of the isoprene molecule, we get at once about 8,000 C_5H_8 groups per unit cell.

B. Cellulose.—As stated before, a single ring, sharp in character and close in to the center, was found on the front film. Since the main beam passes through the hole in this film we do not have the excessive fogging in the center that usually occurs. The entire film, however, is somewhat fogged by general diffusion.

The diameter of this ring was found to be 11 mm., which, assuming first order, leads to the spacing, d = 85.0. This spacing, as will be shown, is open to question.

On the rear film the smallest ring was found to be 12.5 mm. in diameter, which corresponds to a spacing of 274.1 Å. The ring is very slightly elliptical in the direction parallel to the fiber axis. It is of interest to note at this point that spacings of about 150–500 Å. for the micelle length and 20–50 Å. for the cross-section are calculated from line breadths.

The second ring had a diameter of 20.5 mm., which gives a spacing of 168.0 Å. This is apparently the first order of the spacing which is recorded on the front film in the second order. It is possible that these are both higher orders of some spacing that we have not as yet succeeded in resolving from the central beam.

The outermost mark on the film was elliptical in form and had a diameter of 22 mm., giving a spacing of 156.0 Å. This does not [illegible] with any spacing as yet record[illegible]ably indicates a new periodicity. [illegible]est diameter of this ellipse is per[illegible]cular to the fiber axis of the specimen, [illegible]m which we can postulate that this is [illegible]ne of the cross-spacings of the micelle.

This work was the beginning of a complete investigation of long spacings of rubber, cellulose, and other highly polymerized compounds, including proteins and tissues, and will be carried to further and more conclusive results. If in this work it can be assumed that we are measuring the greatest distances in a micelle, then it follows that we have a direct check upon particle size, and it may be possible in the future to take such data and work back to an absolute calculation of particle size from other methods, such as measurement of breadths of diffraction interferences.

SUMMARY

1. A new method for the examination of highly polymerized compounds is proposed. This consists in the direct measurement from diffraction interferences of colloidal micelle dimensions.

2. The construction of an instrument consisting of an X-ray tube with magnesium target and vacuum camera without intervening window or air space is described.

3. The major spacing of unstretched vulcanized rubber is found to be 99.3 Å.

4. The number of isoprene molecules per unit cell is estimated to be of the order of eight thousand.

5. Three measurements of the long spacings of cellulose are recorded.

EXPERIMENTAL STUDIES OF THE MOTILITY OF THE GASTRO-INTESTINAL TRACT OF RACHITIC RATS BY MEANS OF THE X-RAY[1]

By LEON J. MENVILLE, M.D., F.A.C.R., S. N. BLACKBERG, PH.D., and J. N. ANT, M.D., NEW ORLEANS

From the Departments of Medicine and Pharmacology, Tulane University of Louisiana

AS is well known, rickets represents one of the important dietetic diseases of early infancy. It is accompanied by a distinctive pathology of the osseous system, as well as by a marked muscular atony affecting not only the skeletal muscles in general but also the smooth muscular structure of the gastro-intestinal tract. It is for the latter reason that in all marked cases of rickets we find a varying amount of dilatation of the stomach and colon.

The present study was undertaken for the purpose of ascertaining by means of the X-rays the comparative motility of the gastro-intestinal tract of the normal and the rachitic rat. It was considered that such observations would be of value in the interpretation of such disturbances existing in the human host.

In the experiments herein reported about 1,500 radiological exposures were made, including both fluoroscopic and radiographic examinations, upon a total of 80 rats, including both rachitic and normal. The animals used in this work were albino rats raised in our colony from the pure Wistar Institute Stock. The normal controls received a diet of yellow corn, whole wheat, green alfalfa, cotton-seed meal, and 50 per cent of powdered whole milk, containing all the known dietary essentials. These animals grew normally, and were in excellent condition, showing no symptoms of disease.

The rachitic animals were fed the following rachitogenic diet, as recommended by McCollum:

TABLE I

Whole wheat kernel	33.0%
Whole yellow maize kernel	33.0%
Gelatin	15.0%
Wheat gluten	15.0%
NaCl	1.0%
$CaCO_3$	3.0%

One hundred grams of this diet contains 1.221 gm. of calcium, and 0.3019 gm. of phosphorus. Weight of ration, Ca:P = 4.04:1. The proteins of this diet are more than adequate in amount, and are of good

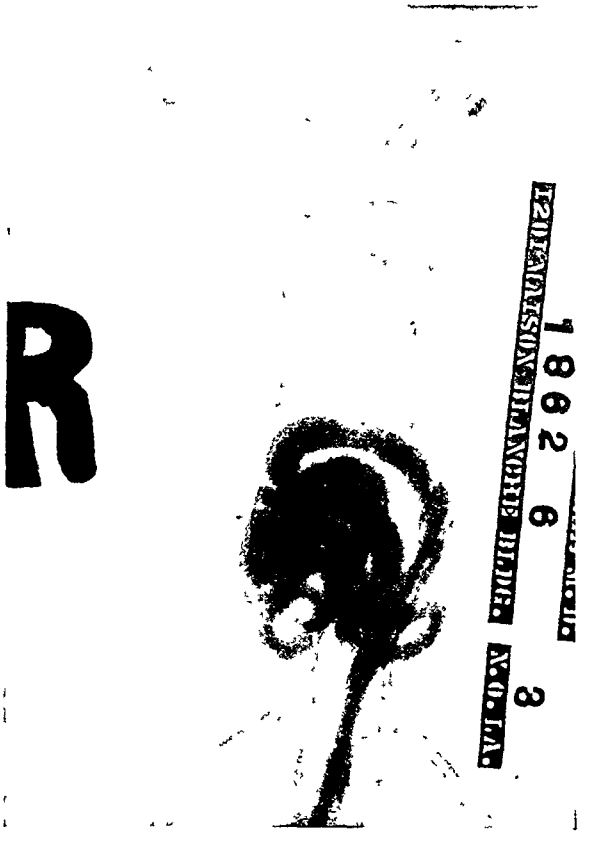


Fig. 1. The visualized colon of a rat shown by means of a barium enema.

[1]Read before the Radiological Society of North America at the Fifteenth Annual Meeting, at Toronto, Dec. 2-6, 1929.



Fig 2 A normal (*left*) and a rachitic (*right*) rat The stomach of the rachitic rat is markedly dilated and atonic in tone Both rats were allowed to eat for twenty minutes and roentgenographed at the same time Note the characteristic bone changes in the *rachitic rat*

quality The calcium content of the ration, 1 221 gm in 100 gm of the food mixture, is about double that required for maximum growth. The phosphorus, 0.3019 gm. in 100 gm of this ration, is far below the amount necessary for the growing rat. When this high calcium, low phosphorus diet is fed to young growing rats for about five or six weeks, they develop an abnormal tottering gait, the animal starting with a hop In the advanced cases there is a weakness of the posterior extremities.

At this time the animals were examined radiologically in order to ascertain whether or not the osseous changes of rickets were present Only those animals revealing positive rachitic bone changes were selected for the experiment. A group of normal animals, consisting of litter mates, when possible, together with the definitely rachitic rats were fasted for from twenty-four to thirty-six hours During this time they were kept in the X-ray laboratory, in order that they might become accustomed to the characteristic noises and to the environment, as we had found in earlier work that rats were easily annoyed and irritated by such noisy surroundings, thereby altering their gastric and intestinal motility

The normal and rachitic groups were fed a mixture of buttermilk and barium sulphate for twenty minutes in individual

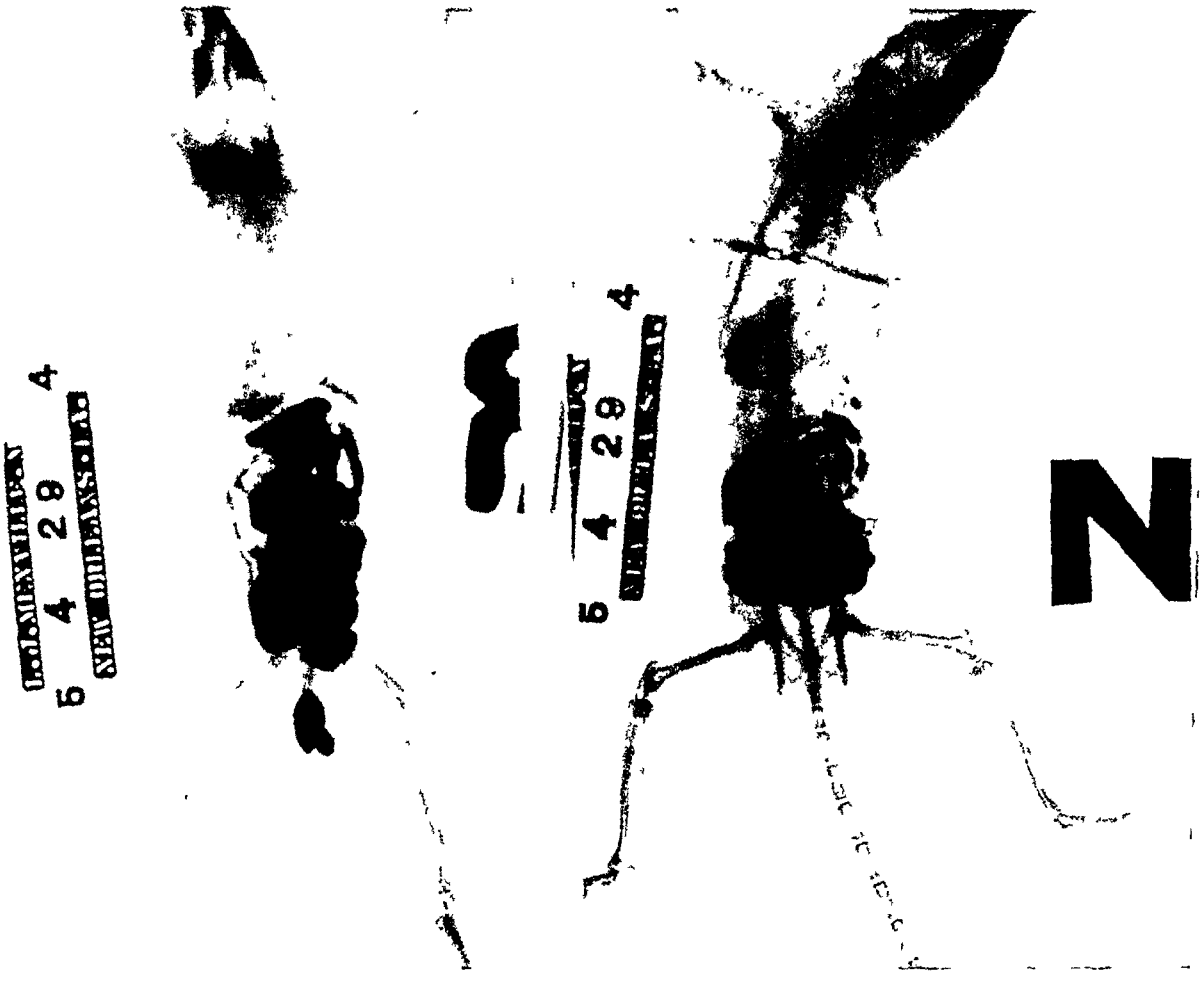


Fig. 3. A normal (*right*) and a rachitic (*left*) rat. The colon of the rachitic rat is markedly dilated and ptosed as compared to the normal rat. Note rachitic bone changes in the rachitic rat. Both rats were fed for twenty minutes and roentgenographed at the same time

cages, the bariumized meal consisting of 10 gm. of barium sulphate and 10 c.c. of buttermilk. The container and the food were weighed before and after feeding, giving us the amount of food consumed by each rat. Immediately after the feeding, the rats were placed in individual cotton bags, so loosely constructed as to permit free access of air and some freedom of movement on the part of the animal, so as not to produce cramping. This bag method was ideal, as the operator could handle the animal freely while fluoroscoping it without fear of being bitten. Each bag was numbered, corresponding to the individual cage number of the rat. After the feeding, the animals were immediately fluoroscoped and a record of the findings were made at this time. In some instances it was deemed advisable to make films of rachitic and normal rats, so as to obtain permanent records of the difference in their gastro-intestinal motility. In such instances the rats were fastened by the leg to a wooden frame, to which manner of handling they offered a certain amount of resistance, distinctly affecting in certain instances the motility of the gastro-intestinal tract. Proper records of these disturbances were made. It should be mentioned in this connection that in the fluoroscopic examination, when the bag method was employed, no interference in the gastro-intestinal motility occurred.

After the first fluoroscopic examination

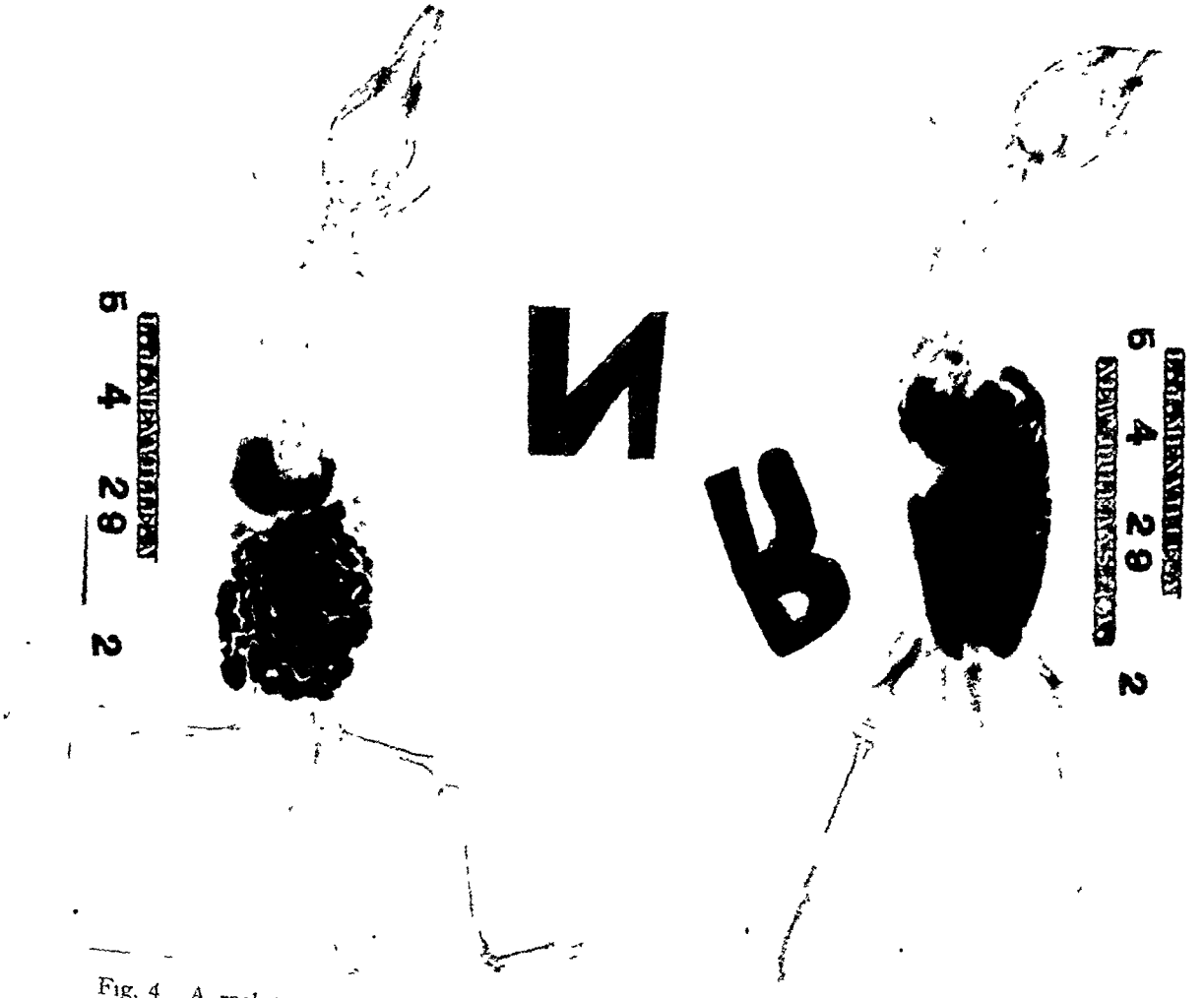


Fig. 4 A rachitic rat, with characteristic bone changes, and a normal rat. Both were fed for twenty minutes and roentgenographed at the same time. The rachitic rat shows that the food column has already reached the colon, which is massed together and ptosed, while the normal rat demonstrates clearly the loops of small intestines, well separated, and that the food column has not yet reached the colon.

was made of the rats they were placed in their individual cages, from which all traces of food had been removed. This precaution is very necessary, as in our early experiments we found that a few of the rats were obtaining food other than that given them. In one instance we found a small amount of barium sticking to the bottom of the container in which water had been placed for drinking purposes. In another instance we suspected a rat of eating his own feces. We accordingly experimented with two rats, fasting them the usual time, and fed them some feces impregnated with barium. Shortly afterward the fluoroscopic examination revealed barium present in their stomachs. This possibility of error was completely removed for all subsequent experiments.

The fluoroscope was used very freely in our observations of the gastro-intestinal motility in both the normal and rachitic groups. Fluoroscopic examinations of the stomach and small intestine were made at intervals as short as fifteen minutes and as long as one hour. In the observation of the colon a much longer interval of time was employed, on account of the slow emptying of this organ. The stomach, small intestine, and colon of the rat, when filled with a bariumized meal, shows very plainly with the fluoroscope. At first, however, we found

some difficulty in distinguishing between a distended small intestine and the cecum. It was very important for us to be able to make a correct distinction, as we were studying the motility of the small intestine, *and the appearance of the food column at* the cecum. In order that we might familiarize ourselves with the position, shape, and size of the colon, we proceeded to purge several rats and gave them a barium enema. The entrance of the barium enema was studied under the fluoroscope while the fluid travelled throughout the colon, at which time a plate was made (Fig. 1). We found that the colon of the rat was redundant and had a greater capacity than was anticipated. The colon when filled with the barium enema made clear the position of the cecum and ileum. Table II demonstrates our finding relative to the motility of the gastro-intestinal tract in both the normal and rachitic groups.

An examination of the above table shows that the normal rats weighed more than the rachitic. In spite of the difference in size and weight, the rachitic rats ate 2 gm. more than the normal. The average emptying time of the stomach of the rachitic rats was two hours and forty-six minutes slower than the normal. The average appearance time of the food column in the cecum of the rachitic rats was one hour and thirty-seven minutes earlier than in the normal. The average emptying time of the small intestine in the rachitic group was two hours and nine minutes slower than in the normal group. The average emptying of the colon in the rachitic group was thirty hours slower than in the normal group.

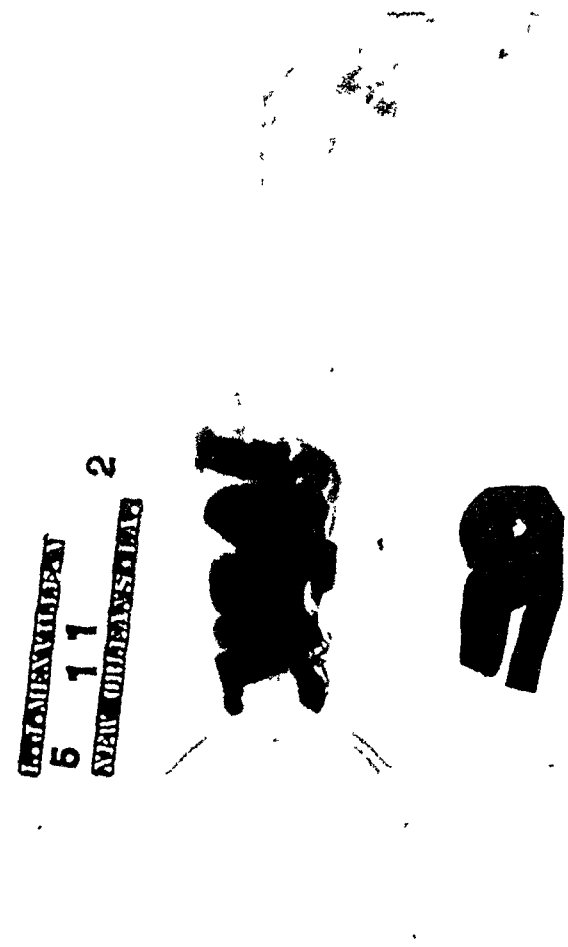


Fig. 5. A markedly dilated colon in the rachitic rat, with an atonic tone, demonstrating beautifully the cause of constipation so often found in cases of rickets.

SUMMARY

The stomachs of the rachitic rats were all dilated and atonic in tone and markedly fish-hook in type, while the stomachs of the normal group were orthotonic in tone and slightly fish-hook in type and showed a marked contrast in tone when compared with the rachitic stomach (Fig. 2). From

TABLE II

	Average Normal	Average Rachitic
Weight of rat	184 gm.	103.1 gm.
Weight of food	6 3 gm.	8 3 gm.
Stomach emptying time	7 hrs. 4 min.	9 hrs. 50 min.
Appearance in cecum	3 hrs. 19 min.	2 hrs. 22 min.
Small intestine emptying time	10 hrs. 36 min.	12 hrs. 5 min.
Colon emptying time	65 hrs.	95 hrs.

observing the early appearance of the food column in the cecum of every rachitic rat, we believe that this demonstrates an apparent hypermotility of the small intestine of the rachitic rat. While we note (see Table II) that the small intestine of the rachitic group empties slower than in the normal, we believe this to be due to the larger amount of food it has to discharge and not to a true hypomotility. The colon of the rachitic group shows a marked hypomotility, however, as evidenced by a dilatation and a very slow emptying time, as well as a ptosed position when compared to the normal group (Fig. 3). The stomach of the rachitic group shows a marked retardation in its motility when compared with the normal group. The atonic and dilated colon observed in these experiments, as shown in Figure 2, demonstrates beautifully the cause of the constipation so commonly found in rachitic subjects.

FORMULÆ FOR THE RAPID CALCULATION OF MILLICURIES OF RADON (EMANATION) DESTROYED AND DOSAGE DELIVERED

By HYMAN L. TEPERSON, M.D., Brooklyn, New York

WHEN treating a lesion with radon we must first determine the number of millicuries of radon which will have to be destroyed in order to deliver the desired dose. For example, if we decide to deliver a dose of 6,000 millicurie-hours to a carcinoma of the uterus, and each millicurie of radon delivers a total radiation of 133.3 millicurie-hours when destroyed, we must divide the 6,000 by 133.3 to determine the number of millicuries required. Although the mathematics involved is elementary, still, when a number of cases have to be figured for, it is time-consuming. A simple formula which reduces the calculation to a mental process is as follows:

$$\text{Formula: } \frac{3}{4} \times \frac{\text{mc. hr. (dose)}}{100} = \text{mc. destroyed.}$$

$$\text{Example: } \frac{3}{4} \times \frac{6000}{100} = 45.$$

To divide by 100, cross off the last two figures and then take ¾ of 60, which equals 45 millicuries. This is the exact amount of radon required and can be proven by multiplying 45 by 133.3.

When using seeds, which are permanently implanted, we obtain their full possible radiation, and, therefore, the number of millicuries of radon with which we start is equal to the number of millicuries of radon destroyed. Ordinarily if we wish to calculate the total dose delivered after complete decay we multiply the number of millicuries of radon by 133.3. A short-cut is the following formula:

Formula:

$$\frac{4}{3} \times \text{mc. radon} \times 100 = \text{mc.-hr. (dose)}$$

Example: What is the total radiation delivered by 45 mc. radon when fully decayed?

$$\frac{4}{3} \times 45 \times 100 = \text{mc.-hr.}$$

$$\frac{4}{3} \times 45 = 60$$

$$60 \times 100 = 6{,}000 \text{ mc.-hr.}$$

Many radium workers follow the method of Regaud, using small amounts of radon over longer periods of time. Four days is the average time of application in our clinic. Fifty per cent of radon is destroyed in four days (3.85 days, to be exact), so that if you wish to deliver the above dose or any given dose in four days, you start with twice the amount of radon which is calculated to be destroyed. Using the same figures as in the above example and by substituting the fraction 2/3 for the fraction 4/3 we get the radiation of half decay (3.85 days).

Formula for half decay period:

$$\frac{2}{3} \times \text{mc. radon} \times 100 = \text{mc.-hr.}$$

$$\frac{2}{3} \times 45 \times 100 = 3{,}000 \text{ mc.-hr.}$$

3,000 mc.-hr. is the dose delivered in four days.

The numbers used, it will be noted, are multiples of 100, but a little familiarity with these formulæ will enable one to calculate numbers in fractions of 100 with equal facility.

SUMMARY

The formulæ given below have proven of aid for radon calculations.

1. Radon destroyed:

$$\frac{3}{4} \times \frac{\text{mc.-hr. (dose)}}{100} = \text{mc. destroyed.}$$

2. Full decay radiation:

$$\frac{4}{3} \times \text{mc. radon} \times 100 = \text{mc.-hr. (dose).}$$

3. Half decay radiation:

$$\frac{2}{3} \times \text{mc. radon} \times 100 = \text{mc.-hr.}$$

CASE REPORTS AND NEW DEVICES

STEREOROENTGENOGRAPHY OF THE MASTOIDS

By W. O. WEISKOTTEN, M D,
San Diego, California

There is some difference of opinion among roentgenologists as to the proper method of making an examination for suspected mastoid pathology. Rather elaborate equipment has been designed with the idea of properly centering the tube and cassette to take advantage of angles which are necessary for the proper projection of the mastoids on the film. Any method which will produce a pair of films showing the greatest contrast and detail of the fine cellular structure of the mastoid, and which is easy to use in everyday practice without the necessity of having especially designed and complicated apparatus, should be the method of choice. For those who still believe that mastoid films made without the Bucky diaphragm give more information and are easier to make, the following method, of course, would not be of interest. However, if routine skull films for suspected fracture or bone pathology are better made with the diaphragm, it is reasonable to assume that the function of the Bucky diaphragm should be applied to the making of a mastoid examination which requires the greatest detail of fine cellular structures. By the same token, we believe that stereoscopic films of both sides for comparison give more information than a pair of so-called "flat" films. There is absolutely no standard as to mastoid development at any given age, but, fortunately, Nature usually makes the mastoids similar in structure in each individual, until pathology develops. The value of comparison, then, is obvious. It takes little additional time and only the cost of one

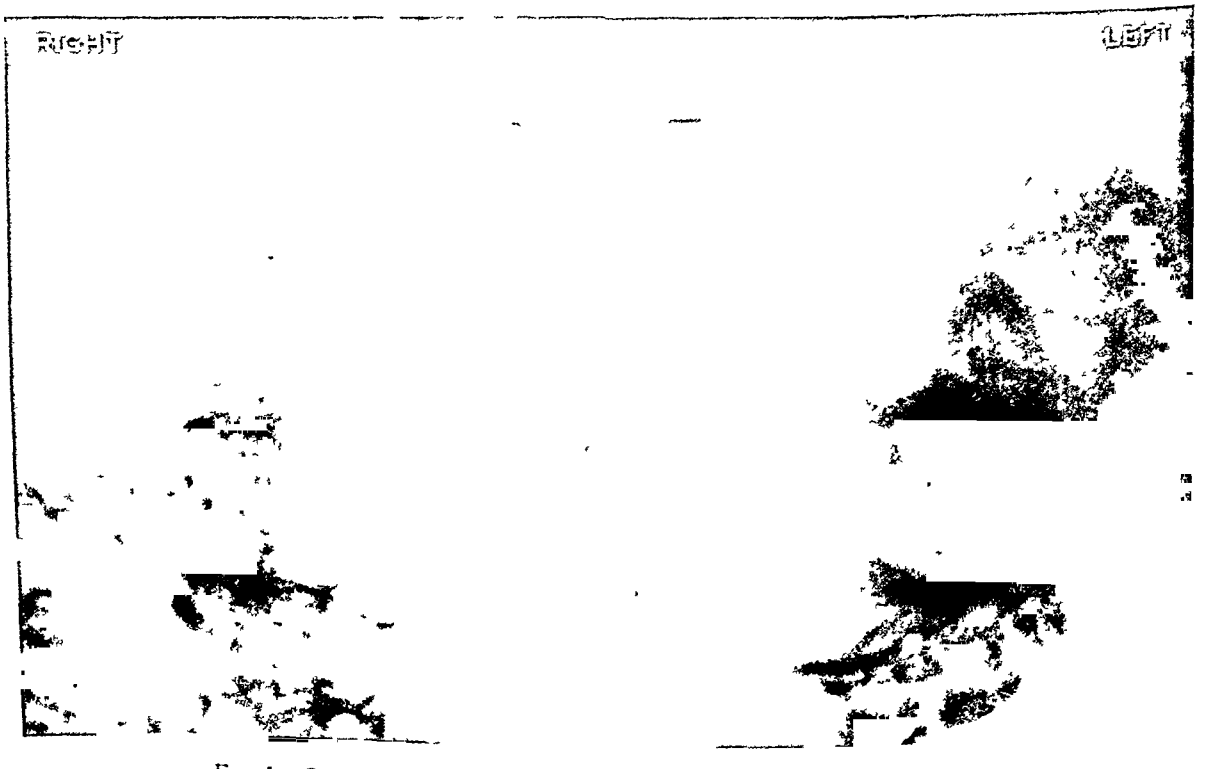


Fig 1 One of a pair of mastoid films illustrating the method outlined

8 by 10 film to complete the mastoid examination properly, if stereoscopic films are made, and this extra time and expense is more than offset by the satisfaction of knowing that nothing is being omitted when films of diagnostic quality are so essential.

In order to standardize the method of exposure and to be able to routinely duplicate the mastoid films, a simple scheme for placing the cassette in the Bucky diaphragm tray is necessary. An L-shaped piece of hardwood, one inch wide, the thickness of the cassette, and with the two sides of the right-angle measuring nine and four inches, respectively, is used as a guide. Two screws, with heads countersunk into the wood, project about one-sixteenth of an inch through the long leg of the wooden angle guide. The 8 by 10 cassette is divided equally by a pencil mark and the center of the left-hand half of the film is accurately centered on the metal tray of the diaphragm. Two holes are drilled through the metal tray to correspond with the screws which project through the wooden angle guide. This guide fits against the lower right-hand corner of the cassette. The 8 by 10 film is then moved towards the opposite side, until the remaining half of the cassette is accurately centered on the tray and two more holes are drilled for the projecting screws of the guide. The center of the 4 by 5 half of the cassette should now correspond with the absolute center mark on the top of the diaphragm. The cassette and guide are now moved back to the first position.

The patient is placed prone on the Bucky table, with chest flat. The left ear is folded forward and the center of the mastoid is placed on the center point of the top of the Bucky diaphragm. The face is inclined towards the table approximately fifteen degrees, and the distance from the tip of the nose to the top of the Bucky is measured. The 8 by 10 film is placed against the guide in the first position and the near side of the cassette is covered with a piece of sheet lead accurately cut and with one edge turned down in order to hold the lead in place. The tube is tilted fifteen degrees towards the feet and accurately centered through the

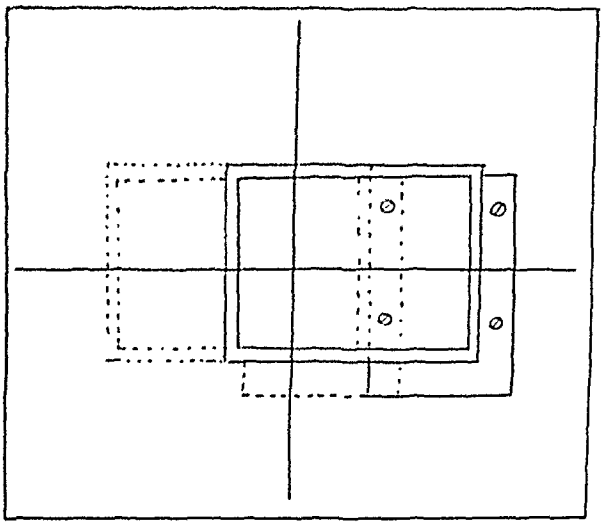


Fig. 2. Metal Bucky diaphragm tray. The cross lines show the center of the diaphragm and the center of half of an 8 by 10 cassette. The dotted lines indicate the second position of the cassette and the wooden angle guide. Sheet lead covers one-half of the cassette in each position.

mastoid to the center of the Bucky top. The tube is now shifted one and one-fourth inches towards the feet, and the first exposure is made. The exposed portion of the first cassette is marked with a pencil and the second cassette is placed in position with sheet lead covering the near half. The tube is now shifted two and one-half inches towards the head (one and one-fourth inches from center position), and the second exposure is made. The cassette is now moved over for the opposite mastoid, with angle guide moved to the second position, which accurately centers the cassette. The lead sheet is now placed over the exposed half of the cassette. Cautioning the patient not to move the chest, the head is rotated carefully, and, with the right ear folded forwards, the right mastoid is centered on the central point of the Bucky top. The distance from tip of nose to top of Bucky is made to correspond with the opposite side.

to insure the same angles for the projection of the two mastoids. Exposure No. 3 is now made, with the tube in the same position as for the second exposure. Both halves of the second cassette are now exposed and the unexposed half of the first cassette is centered by means of the angle guide. The lead covers the first exposure and the tube is shifted towards the feet, or back to its original position. The fourth exposure is now made. The left and right sides are identified with suitable markers at the time of each exposure, and when the films are processed and placed in the stereoscope, the mastoids appear side by side with three dimensions, giving infinitely more information than a pair of "flat" films. The angles used are essentially the standard "fifteen degrees towards the face and fifteen degrees towards the feet." With proper exposure factors of time, milliamperes, and kilovolts, and with a twenty-five to thirty inch target film distance, satisfactory films will be obtained every time this method is used. Of course, a fine focus tube gives better detail than a tube with a broad focal spot. The whole method is simple and rapid, and the operator is rewarded with a pair of films which will allow accurate interpretation. The relation of tube stand to Bucky diaphragm should be permanently established, and with position of cassettes determined, the only variable factors are the position of the patient and variation in exposure to compensate for individual skulls.

No originality is claimed for the method of making stereoscopic mastoid films side by side on two 8 by 10 films, but the details of standardizing the procedure have been worked out with the idea of consistently producing diagnostic films with the least amount of trouble, and with the equipment found in any general X-ray laboratory.

One of a pair of films is shown (Fig. 1) and the accompanying diagram gives an idea of how the cassettes are placed on the metal Bucky tray.

MEASUREMENT OF CURRENT DURING SHORT EXPOSURES

By M. M. SCHWARZSCHILD, M.A.,
Physicist, Beth Israel Hospital, NEW YORK CITY

Recently there has appeared in Germany a ballistic milliamperemeter. The instrument is produced by Hartman and Braun and permits the measurement of current flowing for very short periods of time. Prior to the announcement of this new meter the author devised a circuit, herein described, which makes possible such measurements with apparatus readily available at a reasonable cost. Because of the simplicity of the arrangement it ought to be of interest to those who wish to control rapid exposures.

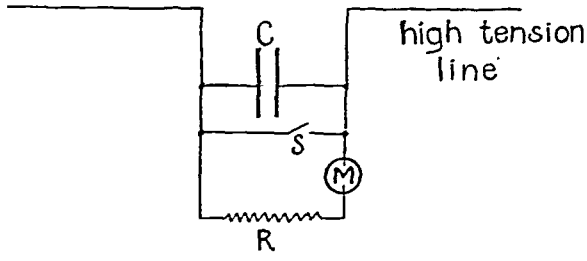


Fig. 1. Circuit of milliampere-second meter.

The elements of the circuit are shown in Figure 1. *C* is a condenser of high capacity; in the author's model it consists of 25 paralleled condensers of 10 microfarads each, capable of withstanding 200 volts. *R* is a resistance, in the present model, 200,000 ohms. *M* is a milliamperemeter. In the present model the full scale deflection is 1 milliampere. *S* is a simple switch. The device is connected as indicated, in series with the tube, and must, of course, if there is no center tap on the transformer, be mounted on an insulated support.

The operation of the device is as follows: Prior to making an exposure the switch *S* is closed for about a minute in order to completely discharge the condenser. The switch

is then opened and the exposure made. Practically the only current flowing through the device is the charging current of the condenser, so that at the close of the exposure the condenser is charged. The voltage of the charged condenser is readily seen to be $\frac{1000it}{c}$ where i is the current through the high tension circuit in milliamperes, t is the time of the exposure in seconds, and c is the capacity of the condenser in microfarads. Due to this voltage difference a current will flow through R and M after the exposure is ended. This current in milliamperes is evidently equal to $\frac{it}{cR}$ where i, c, and t have their previous meanings and R is the resistance in ohms. Evidently, then, the current indicated on the meter M is a direct measure of the product $i\,t$, or the milliampere-seconds of the exposure.

The values of R and c are so selected that the time constant of the discharge through R is such that the drop in current during the first second after the exposure is inappreciable. In the case here considered the drop in current, and hence in the reading of M after one second, is only 2 per cent of the total deflection. It is thus a simple matter to read the meter quite accurately.

The maximum range of the instrument is fixed by the breakdown voltage of the condenser battery which must not be reached. The range in milliampere-seconds is given by $\frac{Vc}{1000}$ where c is the capacity of the condenser battery is microfarads and V the maximum safe D.C. voltage of the condenser. In the case here considered the maximum range is 50 milliampere-seconds.

Condensers of the high capacity desirable here are easily obtainable at radio shops, since they are important elements of the ordinary radio battery eliminators. The rated value for the capacity cannot be relied on, so that the device should be calibrated with known exposures.

A series of measurements made with this device and a synchronous timer shows very good agreement on longer exposures (1/30–1/4 sec.), but the agreement is not quite so good for shorter exposures, there being

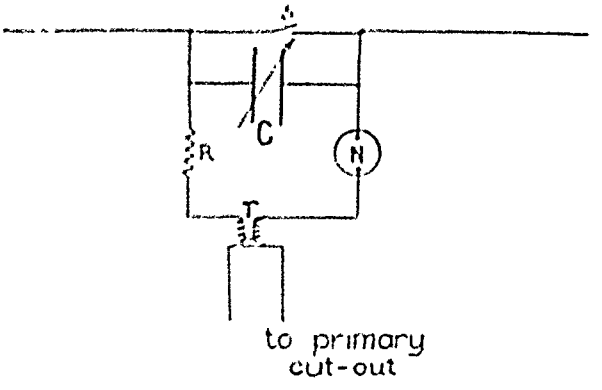


Fig. 2. Circuit of proposed milliampere-second timer.

always a disproportionate rise for the shorter exposures. In order to test the apparatus to decide whether this apparent discrepancy is due to a defect in the device or to actual change in output of the X-ray machine, the radiation output was measured with an ionization chamber. The deflections for short exposures were too small to permit of accurate reading, so that readings were taken at longer intervals, and then at the same exposure for repeated short periods. A set of test runs on the device and on the ionization chamber resulted as follows: The meter showed an increase of 20 per cent in current for an exposure of 1/120 sec., as against one of 1/4 second. The ionization measurement showed an increase of 13 per cent in ionization for 30 exposures of 1/120 sec. each, as against a single exposure of 1/4 second. Exact agreement could not be expected as the two methods measure very different quantities, but there is undoubtedly a difference betwen the circuit behavior at short exposures as against long ones. The differences are probably due to the fact that for very short exposures (1/120–1/30 sec.)

transient phenomena enter into the operation of the high voltage system, so that the milliampere readings taken with an ordinary

trolled by the number of milliampere-seconds, rather than by the time alone. This suggestion is made without any actual ex-

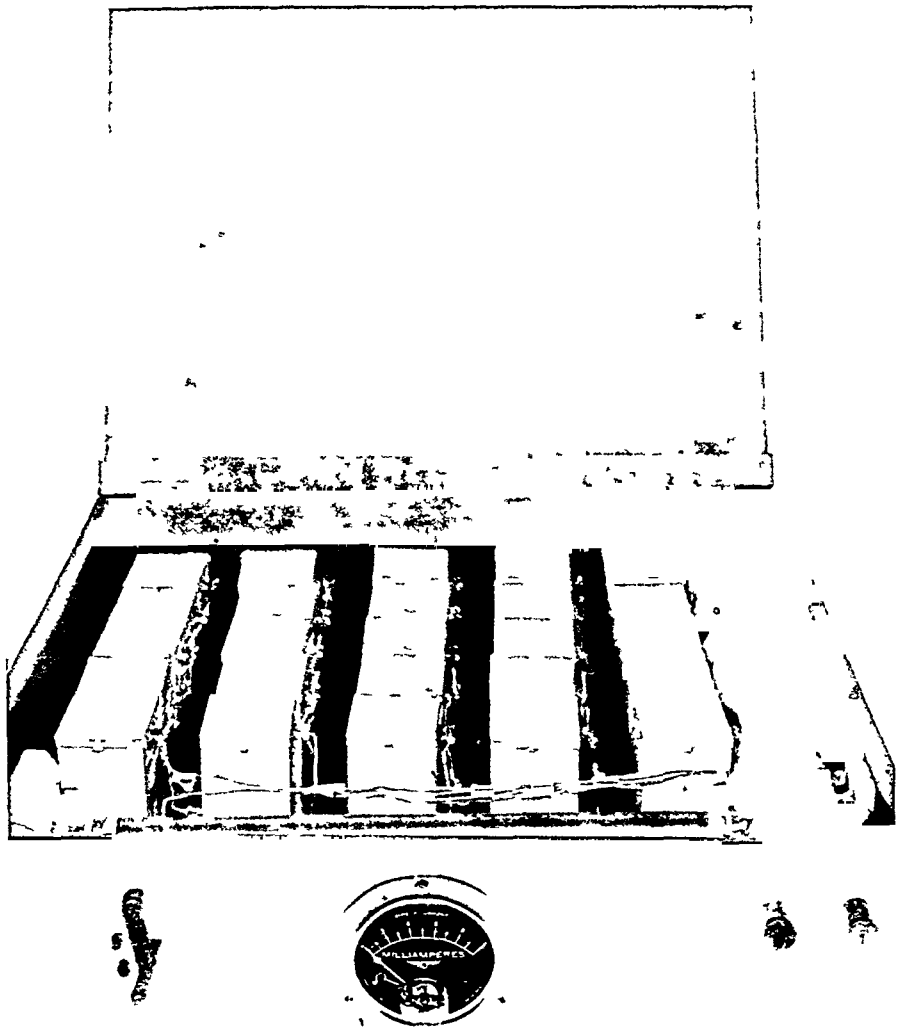


Fig 3 Present model of milliampere-second meter

milliammeter cannot be trusted If this is the case, a method of exposure control involving the use of a system of this kind, or of a ballistic milliammeter, is highly desirable

This device may be modified in such a way as to make it an effective milliampere-second timer, so that exposures can be con-

perience with such an arrangement, but with full confidence as to its practicability. The circuit for such an arrangement is shown in Figure 2 N is a neon or other gas tube having a definite breakdown voltage R is merely a protective resistance for the tube and the relay r, which operates a primary cut-out. The whole system is connected in

the place of, or in series with, the milliammeter, where the latter is at ground potential (center tapped transformer and rectifier). The condenser C is made variable so that it may be set for different exposures. When the exposure has progressed to the desired point, the condenser discharges through the neon tube and relay, thus opening the primary circuit. Such a timer would be extremely accurate, and would, by its very nature, compensate for fluctuations.

PORTABLE RADIOGRAPHIC AUTOPSY EXAMINATION

By PAUL F. TITTERINGTON, M.D., St. Louis

During the St. Louis cyclone of September, 1927, a workman for one of the large factories was killed. Eighteen months later, the exact cause of death was a disputed question. An autopsy committee was appointed to determine whether death had been caused by direct violence or by burns from bursting steam pipes.

The condition of the body at the time of death prevented thorough embalming. Upon exhumation, it was found that the poor state of preservation prevented the body's removal from the casket.

All exposures were made on films loaded in cardboard holders so that they could be discarded after use. The exposures of the shoulders, entire spine, pelvis, and legs were made through the bottom of the casket on films placed under it. The upper portion of the body could be raised sufficiently high and fixed in position so that the head extended above the sides of the casket. Films were then placed at the sides of and under the skull.

The machine used was a five-inch G. E. portable with a thirty-milliampere radiator tube. The exposures varied from thirty to seventy-five seconds at a forty-inch distance.



Fig. 1. Right leg, showing fracture. Exposure was made through the casket.

The radiographic findings are of interest. The thoracic and abdominal viscera had been removed and the cavities packed with formaldehyde sawdust. The roentgenogram of the chest had the appearance of a miliary tuberculosis, due to the sawdust. No diaphragms were demonstrated. A large



Fig. 2. Skull, showing shrinkage of the brain.

ment. There was distinct improvement, resulting in a thickening of the cortex and a beginning filling in of the areas of rarefaction. In this case there is no change in growth, a year later.

Case 4. Male child, aged 11 years. This case is one I showed a year ago, and some of you may be interested in seeing an X-ray film made a year later (Fig. 3-*A*). This was a very large expanding tumor at the lower end of the radius. It was given treatments with medium voltage at weekly intervals from three sides, five minutes for each area at each weekly sitting. It responded very favorably. Now the epiphyseal region was distinctly radiated in this case and growth was not disturbed. The tumor has shrunken down and filled in with bone except for a few areas (Fig. 3-*B*). A comparison of the two sides shows that the bone is practically normal from the epiphyseal line down for about two inches. There are still one or two very small rarefied areas which I think we can disregard so far as likely to give any trouble in the future. The patient had treatment for about a year and a half, and now it is a year and a half since treatment ceased. There has been no disturbance in the growth of the bone in this case.



Fig. 3-*A*. Case 4. Giant-cell tumor of the lower end of the right radius.

Fig. 3-*B*. The same case, three years and five months after roentgen therapy. There has been no disturbance in growth.

Dr. Desjardins is to be congratulated on the excellent therapeutic result in his case.

CONCLUSIONS

Benign giant-cell bone tumors, or osteitis fibrosa cystica, can be satisfactorily treated by moderate voltage X-ray. Biopsy is not essential, as the response to the X-ray treatment may be taken as a confirmation of the X-ray diagnosis.

EDITORIAL

M. J. Hubbard, M.D. *Editor*
Benjamin H. Orndoff, M.D. . . *Associate Editor*

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JOINING HANDS IN RESEARCH AND IN A NEW "RADIOLOGY"

With this first number of a new volume there begins also a new chapter in the scope and service of RADIOLOGY. Its activities have been confined through the years to the medical science of radiation, particularly X-rays, because that was the purpose for which it was created. In the opinion of disinterested observers the journal has recorded faithfully notable research efforts and reflected progress in technic and advancement in theoretical knowledge. Most of the contributors have been members of the medical profession who necessarily had to combine in their own training and experience as many branches of the many-sided science of X-rays as possible, the interest, however, being in improved diagnostic and therapeutic applications.

Contemporary with these medical researches have been those in laboratories of the other sciences. The physicist has been interested in the radiation as such, the measurement of spectral wave lengths, determination of the laws of emission, absorption, and scattering, and the relationship of experimental facts to the structures of atoms. The chemist has come to use X-rays as one of the greatest new tools in the study of the ultimate fine structure of matter, and, of course, he has been further concerned with the effect of X-rays upon chemical reactions as a part of the rapidly growing branch of photochemistry. The biologist has largely confined his use of X-rays to the field of genetics, the effects of irradiation on growth, reproduction, and characteristics of future generations. More recently we find sprouting a tremendous industrial science of X-rays in which fundamental properties of these rays, such as the penetrating power, employed for thirty years in medical radiography for diagnosis and now for examining the interior texture of any material from cast steel to golf balls, and diffraction by solid crystals, are utilized in the solution of difficult research problems and for routine testing of manufactured articles.

It is inevitable that the science of X-rays has become so ramified that the various branches have little or no contact with each other. Men become expert radiologists in one field and yet remain in ignorance of the problems and achievements of other men using the same radiation to different ends The inevitable result is overlapping of effort and a progress towards the goal of knowledge which is delayed and incomplete. More and more in this complex age of civilization and of specialization in some narrow corner within a sub-branch of some science, is growing the *clinical idea*—a joining of effort with each specialist contributing to the common cause of science his own best efforts and his own experimental observations. It cannot be expected that the medical radiologist or roentgenologist should be able to combine in himself expert knowledge of anatomy, physiology, histology, photochemistry, physics of radiation, engineering details of equipment and other specialized research fields, any more than the physicist should know cell structures or the chemistry of protoplasm.

After all, however, the medical applica-

tion of X-rays—diagnosis and alleviation or cure of suffering—transcends all others. Back of all the X-ray research on extending accuracy of wave length measurement to a few more decimal points, or on analysis of the ultimate structure of steel, or rubber or anything else imaginable is the hope that some new fact or phenomenon may come out which may be useful where the human body is the specimen. And yet there has been little or no opportunity for the radiologist to learn what the X-ray chemist or physicist or biologist or engineer is doing and could do in helping to solve medical problems, the most difficult and important of all, unless he should read papers scattered widely through all sorts of American and foreign journals. Similarly, the research chemist and physicist has had little opportunity to learn wherein he can contribute information and expert assistance in rendering radiology and roentgenology more exact sciences.

To introduce the *clinical idea of research,* to enable joining of hands and of effort by mutual acquaintanceship, mutual interchange of results and dissemination of information of interest and value to all, and to further the science of X-rays and related radiation in general and the medical applications in particular to greater achievements in behalf of human welfare, are the motives involved in the expansion of RADIOLOGY which has been made possible through the generosity of the Chemical Foundation and the keen vision of its responsible authorities. The former scope of the journal has been widened and deepened by the addition of a research division. In selecting the advisory staff of this division to include interests along every line of radiation research, the department editor made bold to choose names of unquestioned international reputation, and not a single rejection was received. This in itself is evidence of the long-standing need for co-operation and of the unselfish spirit of research which is now brought into fruition. Because of irrepressible faith in the science it is the hope to make of RADIOLOGY the greatest journal of its kind, transcending the boundaries of any nation and of any science by bringing within its covers accounts of all great discoveries and every detail of progress in the use of a great research instrument.

At first sight the roentgenologist may wonder what concern he has with X-ray crystallography. Let him but read thoughtfully in this issue the masterly and inspiring introductory paper by Dr. J. D. Bernal, of the University of Cambridge, England. He will understand then not only the vast importance of the field but also the actual application directly to the structure determination of tissues in the human body as X-rays carry us to an undreamed-of science of super-histology and an entirely new method of diagnosis. Every reader, whatever his interest, will find highly useful the paper by Dr. R. W. G. Wyckoff, of the Rockefeller Institute, in which is described in detail a remarkably efficient, essentially home-made X-ray tube for general research purposes. Dr. Glasser, already a familiar figure to the readers of RADIOLOGY, presents his great paper on the measurement of γ-rays. And so with other papers, these are but indications of the ideals and ambitions which shall make of RADIOLOGY a greater and more versatile handmaiden of science and servant of mankind. The journal remains the official organ and property of the Radiological Society of North America, but with fine vision the Society has understood and answered the challenge for greater opportunities and wider usefulness.

Under the frontispiece of "Chemistry in Medicine," a portrait of a beautiful little girl, Patricia, daughter of Mr. and Mrs. Francis P. Garvan, appear these words: "May the memory of lost children urge us on." This child lost her life because science

had not advanced far enough to save it. With abiding faith in the immensity of things unfolded by scientific research, these parents and the Chemical Foundation have now made it possible for us to accept the challenge and through the medium of a greater Radiology as a common meeting ground, to move on to undreamed-of heights of scientific achievement.

George L. Clark, Ph.D.

THE RÖNTGEN MEMORIAL

It is proposed by the Rheinisch-Westfälische-Röntgen Society, through its founder and President, Prof. P. Krause, in Münster, that a life-size monument of Röntgen be erected in his birthplace of Lennep. The city of Lennep has given the most beautiful spot in the town for this purpose, and the cost of the monument is being raised by voluntary subscription.

American roentgenologists are invited to contribute to this fund, and it is hoped that a sum of $2,500, which is a quarter of the cost of the monument, can be raised in this country. Upon consultation with the Presidents of the Radiological Society of North America and the American Roentgen Ray Society, it was decided to send out letters asking for donations. Thirteen hundred and eighty letters were sent to radiologists on March 15, 1930. Over a hundred generous contributions have been received, the total sum collected thus far being $900. It is hoped that the remaining $1,600 will be contributed by the 1,200 roentgenologists who have not yet responded.

Checks should be sent to Otto Glasser, Ph.D., Cleveland Clinic Foundation, 2050 E. 93rd St., Cleveland, Ohio. The funds which are collected will be transferred to the "Denkmalsfonds der Rhein, Westf. Röntgengesellschaft" of the "Deutsche Bank, Duesseldorf," and the names of the contributors will be sent to Prof. P. Krause, 3 Wetring, Munster, i. W., Germany.

PROGRAM OF THE EDUCATIONAL COMMITTEE FOR 1930

1. To encourage the members, officers, and counsellors of the Radiological Society of North America to present educational material before lay audiences and to the general medical profession. Also to present editorials in our own journal Radiology and especially in other medical journals going out to the general medical profession. These talks, editorials, or papers should tend to bring out the thought that the practice of radiology is a specialty and that the radiologist is a physician and a medical specialist.

2. To encourage presentation of editorials in Radiology which point out that radiological practice is a medical specialty and that the radiologist should make every effort to qualify as a specialist in radiological work.

3. To disseminate propaganda tending to educate the public to the fact that the average physician or surgeon cannot do as good radiological work as the specialist in radiology.

4. To carry on investigation by correspondence of reported cures for malignancy and the results of research and experimental work being done in malignancy, results of this investigation to be given to the membership of the Society through Radiology.

5. To encourage the membership to send in to the Committee material of an educational nature tending to help radiology. The Educational Committee will see that this material is published through the various periodicals of the country, both lay and medical.

6. To endeavor to secure the co-operation of the American Medical Association.

the College of Physicians, and the College of Surgeons in a campaign tending to put before the general profession that the radiologist is also a physician. As he is a duly qualified medical man and also a specialist in radiology the profession should expect radiological work of the highest quality.

7. To continue our educational work through the lay press and the periodicals of the country which was started last year. This educational work should also tend to show that the radiologist is a qualified medical man.

B. C. CUSHWAY, M.D.
ALDEN WILLIAMS, M.D.
W. W. WASSON, M.D.
Committee.

THE AMERICAN SOCIETY OF RADIOGRAPHERS

The seventh annual meeting of the American Society of Radiographers was held at the Sherman Hotel, Chicago, Illinois, April 28, 29, 30 and May 1, 1930.

The decision was made at the meeting to change the name of the organization from the American Association of Radiological Technicians to the American Society of Radiographers.

A committee was appointed for the purpose of investigating the proper procedure for raising the standards of the Society and, also, a committee to take up the matter of affiliation of the British Society of Radiographers, the Canadian Society, and others, with the American Society of Radiographers.

Papers on technical subjects, pertaining to the radiographers' art, were presented by members of the Society and medical men. These papers will be published in the official journal of the American Society of Radiographers, *The X-Ray Technician.*

From the following partial list of subjects and speakers it will be seen that the whole country is represented and the range of subjects covered of practical application: R. S. Landauer, Ph.D., Chicago, "Discovery and Early History of X-rays"; C. Turner, Chicago, "Development and Early History of Transformer which Makes X-rays Possible"; C. J. Bodle, R.T., Winnipeg, Man., Canada, "Voltage Measurement in Radiography"; Albert C. Nelson, Chicago, "Development and Design of X-ray Apparatus"; H. H. Ingram, Rochester, N. Y., "Fundamentals of X-ray Photography"; V. C. Baldwin, R.T., Covington, Ky., "Dark-room Procedure"; Sister M. Catherine, R.T., Iowa City, Iowa, "Radiographic Chemistry"; Isabel Rutter, R.T., Uniontown, Penn., "Practical Application of Roentgen Ray in Mastoid Technic"; H. O. Mahoney, Chicago, "Analyzing a Poor Radiograph"; Augusta G. Thomas, R.T., Memphis, Tenn., "Clinical Photography"; J. S. Cowles, St. Louis, "Controlling Factors of Dark Room"; Lavilla M. Perry, R.T., and E. S. Newton, Salem, Oregon, "Rib Position and Radiographic Technic of Mid-axillary and Mid-clavicular Lines"; Sister M. Maxentia, R.T., Minneapolis, "Radiographing of Kidneys"; Gertrude Johnson, R.T., Altoona, Penn., "Do You Know?" Glenn W. Files, R.T., Chicago, "Radiographing of Chest"; Virginia H. Eller, R.T., Janesville, Wis., "Heart Graphing as Duty of Technician—Its Technic"; W. W. Pollino, R.T., Brooklyn, N. Y., "Fast Exposure in Teleoroentgenography"; Harold G. Petsing, R.T., Chicago, "Prevailing Opinions Regarding Radiography of Chest"; H. A. Tuttle, R.T., Chicago, "Some Thoughts on Radiography"; Anna R. Bolin, Chicago, "Roentgenological Research in Natural History"; Gentz Perry, M.D., Evanston, Ill., "Ethics"; M. T. MacEachern, M.D., Chicago, "Planning, Organization, and Management of X-ray

Department in Hospital"; Chester H. Warfield, M.D., Chicago, "Routine Work in Large X-ray Department"; George M. Landau, M.D., Chicago, "To Whom may X-ray Films be Shown?" Jerome R. Head, M.D., Chicago, "Technic and Procedure in Using Lipiodol and Raying of Chest"; Henry Schmitz, M.D., Chicago, "Progress in Radiation Treatment of Uterine Cancer"; Hans A. Jarre, M.D., Detroit, "Cinex Camera—Its Value to Busy Roentgenologic Laboratory"; William E. Redlick, D.D.S., Chicago, "Simplified Dental Radiographic Technic"; L. P. Kuhn, M.D., Chicago, "Myositis Ossificans Traumatica—Special Considerations for Technicians"; Mabel Walsh, R.T., Chicago, "Routine Technic in Demonstrating Gall-bladder Function after Administration of Dye"; H. N. Beets, Chicago, "Commonsense Radiography."

The first issue of *The X-Ray Technician* appeared in July, 1929, and met with an enthusiastic reception by X-ray technicians and the medical profession all over the world. There are at present eighty subscriptions from London alone.

The following officers were elected for the coming year:

President, Mrs. E. C. Grierson, R.T., 1476 Selby Ave., St. Paul, Minn.; *First Vice-president* and *President-elect,* Miss Margaret Hoing, R.T., 2561 North Clark St., Chicago; *Second Vice-president,* Miss Emma L. Stewart, R.T., 829 Starks Bldg., Louisville, Ky.; *Third Vice-president,* Sister Mary Artos, R.T., Sacred Heart Sanatorium, Milwaukee, Wis.; *Secretary-Treasurer,* Mary E. Bell, R.T., New Asbury Hospital, Minneapolis, Minn.; *Executive Committee:* H. A. Tuttle, R.T., Chicago, F. A. Senechal, R.T., St. Louis, C. J. Bodle, R.T., Winnipeg, Man., Canada.

Mr. E. C. Jerman has been elected President Emeritus of the American Society of Radiographers.

St. Paul, Minnesota, was chosen as the meeting place for the annual convention in May, 1931, the time of the month to be decided upon at a later date by the Executive Committee in order to avoid conflict with medical meetings.

MARY E. BELL, *Secretary-Treasurer.*

QUESTIONNAIRE CONCERNING THE TRIP TO PARIS NEXT SUMMER

At the suggestion of I. Seth Hirsch, M.D., the following questionnaire is presented to the attention of all readers in North America, who would naturally sail from New York. It has to do with plans for travelling in a group, at materially reduced rates, to the Third International Congress on Radiology, scheduled to meet in Paris July 27 to 31, 1931. It will readily be seen that to reply to the questionnaire as promptly as possible is a constructive step in the formation of coherent plans to get the very most out of the trip to the Continent.

If interested, please write to Dr. I. Seth Hirsch, 136 East 64th Street, New York City, letting your letter take the form of a reply to the following questions:

1. Do you intend to be present at the Third International Congress on Radiology in Paris in 1931?
2. Will you be accompanied by members of your family?
3. Would you prefer to sail so as to arrive two weeks in advance of the meeting?
4. Would you prefer to sail so as to arrive a few days before the meeting?
5. When do you intend to return?

A very low rate can be obtained from a trans-Atlantic line for a one-cabin ship. The rates can be made particularly low if those attending come back as a group.

SECTION ON RADIOLOGY AMERICAN MEDICAL ASSOCIATION

June 25, 26, 27, 1930

Chairman's Address.
FRED M. HODGES, M.D., Richmond, Va.

Radium in Benign Lesions of the Skin.
FRANK E. SIMPSON, M.D., Chicago, Ill.
Discussion to be opened by E. H. SKINNER, M.D., Kansas City, Mo.

X-ray in the Treatment of Infections.
A. U. DESJARDINS, M.D., Rochester, Minn.
Discussion to be opened by ROLLIN H. STEVENS, M.D., Detroit, Mich.

Irradiation of Mammary Cancer, with Special Reference to Measured Tissue Dosage.
BURTON J. LEE, M.D., and GEORGE T. PACK, M.D., New York, N. Y. (By Invitation.)
Discussion to be opened by HENRY J. ULLMANN, M.D., Santa Barbara, Calif.

Cancer of the Mouth—Its Prevention and Cure.
GEORGE E. PFAHLER, M.D., and JACOB H. VASTINE, M.D., Philadelphia, Pa.
Discussion to be opened by GEORGE W. GRIER, M.D., Pittsburgh, Pa.

Indications and Limitations for Intensive Roentgen-ray and Radium Treatment of Advanced Cancer.
BERNARD P. WIDMANN, M.D., Philadelphia, Pa.
Discussion to be opened by ALBERT SOILAND, M.D., Los Angeles, Calif., and FRANCIS CARTER WOOD, M.D., New York, N. Y.

Comments on Cancer Treatment.
ALBERT SOILAND, M.D., Los Angeles, Calif.
Discussion to be opened by DOUGLAS QUICK, M.D., New York, N. Y.

Lymphomalignum (Hodgkin's) and Lymphosarcoma: Pathogenesis, Radiotherapy and Prognosis.
ISAAC LEVIN, M.D., New York, N. Y.

Semilunar Malacia.
E. S. BLAINE, M.D., Chicago, Ill.
Discussion to be opened by CARROLL E. COOK, M.D., Chicago, Ill., and HOWARD P. DOUB, M.D., Detroit, Mich.

Roentgenographic Studies in Normal Osseous Development.
E. K. SHELTON, JR., M.D., Santa Barbara, Calif.
Discussion to be opened by BUNDY ALLEN, M.D., Tampa, Fla.

Encephalography and Ventriculography: Their Indications and Contra-indications.
EUGENE P. PENDERGRASS, M.D., Philadelphia, Pa.
Discussion to be opened by TEMPLE FAY, M.D., Philadelphia, Pa.

Intravenous Urography (Swick Method).
LEOPOLD JACHES, M.D., New York, N. Y.

Cholecystography: An Analysis after Six Years' Application.
SHERWOOD MOORE, M.D., St. Louis, Mo.
Discussion to be opened by JAMES T. CASE, M.D., Chicago, Ill.

Roentgen Diagnosis of Ascariasis.
VINCENT W. ARCHER, M.D., University, Va.
Discussion to be opened by EUGENE P. PENDERGRASS, M.D., Philadelphia, Pa.

Hyperplastic Tuberculosis of the Duodenum and Terminal Ileum.
JOHN DAY GARVIN, M.D., Pittsburgh, Pa.
Discussion to be opened by LAWRENCE REYNOLDS, M.D., Detroit, Mich.

A Roentgenological Study of the Chest in Rachitic Children.
RALPH S. BROMER, M.D., Philadelphia, Pa.
Discussion to be opened by WILLIAM A. EVANS, M.D., Detroit, Mich.

Roentgenologic Diagnosis of Diaphragmatic Hernia.
A. B. MOORE, M.D., and B. R. KIRKLIN, M.D., Rochester, Minn.
Discussion to be opened by E. L. JENKINSON, M.D., Chicago, Ill.

Correlation of X-ray Measurements of the Heart with Clinical Condition of the Patient.
SINCLAIR LUTON, M.D., St. Louis, Mo.
Discussion to be opened by HAROLD E. B. PARDEE, M.D., and LEON T. LE WALD, M.D., New York, N. Y.

Spontaneous Pneumothorax.
ROBERT B. TAFT, M.D., Charleston, S. C.
Discussion to be opened by JOHN M. BARNES, M.D., Ann Arbor, Mich.

The Roentgen Diagnosis of Small Pleural Effusions, with Observations of the Movement of Pleural Effusions.

Leo G. Rigler, M.D., Minneapolis, Minn.

Discussion to be opened by L. R. Sante, M.D., St. Louis, Mo.

FIFTEENTH ANNUAL CLINICAL SESSION OF THE AMERICAN COLLEGE OF PHYSICIANS

The American College of Physicians will hold its Fifteenth Annual Clinical Session at Baltimore, Maryland, from March 23 to 27, inclusive, 1931. The Lord Baltimore Hotel will be headquarters.

Dr. Sydney R. Miller, of Baltimore, as President, will have charge of the selection of the general scientific program. Dr. Maurice C. Pincoffs, of Baltimore, has been appointed by the Board of Regents as the General Chairman of the Session, and will have charge of all local arrangements, including the making up of the program of clinics. Business details will be handled by the Executive Secretary, Mr. E. R. Loveland, from the College headquarters, 133-135 S. 36th Street, Philadelphia, Pa.

The attention of secretaries of various societies is called to the above dates, in the hope that their societies will select non-conflicting dates for their 1931 meetings.

A POST-GRADUATE WEEK OF PHYSICAL THERAPY

To be Conducted by the American Congress of Physical Therapy

Announcement is made of "A Post-graduate Week of Physical Therapy" in conjunction with the ninth annual scientific session of the American Congress of Physical Therapy, to be conducted September 8 to 12, inclusive, 1930, at the New Hotel Jefferson, St. Louis, Mo.

An intensive post-graduate week of physical therapy is promised. Elaborate plans have been perfected for teaching, demonstrations, and clinics. The physician who is interested in physical therapeutics and who has not had any instruction in the work will find the lectures on the fundamentals a sound basic means for further study. The more experienced, on the other hand, will gain considerably from the advanced expositions on light, heat, electricity, massage and all the other physical agents utilized in practice. Every phase of physical therapy will be covered. The subjects will be general and specific and so varied as to appeal to both the general practitioner and the specialist.

While it is appreciated that a week is a rather short period for post-graduate teaching, the systematic arrangement of the program makes it possible for the physician to attend only those sessions in which he is vitally interested. As has been the practice in the past, sectional gatherings will prevail in medicine, surgery, and eye, ear, nose and throat. Several of the afternoons and evenings will be given over to addresses by prominent guests. There will be symposia on "Education and Teaching of Physical Therapeutics" and on "The Relation of the Physician and the Technician in Office and Hospital Practice."

New features in the conduct of clinics and demonstrations will be observed. In fact, so many new features have been arranged that they cannot be enumerated here. The preliminary program will be issued within a short time. Full information and details are contained in it. Send your name and address to the Executive Secretary, American Congress of Physical Therapy, Suite 716, 30 N. Michigan Avenue, Chicago, Ill.

THE JOHN PHILLIPS MEMORIAL PRIZE

The American College of Physicians announces the John Phillips Memorial Prize

of $1,500, to be awarded for the most meritorious contribution in internal medicine and sciences contributing thereto, under the following conditions:

(1) The contribution must be submitted in the form of a thesis or dissertation based upon published or unpublished original work.

(2) It must be mailed to the Executive Secretary of the American College of Physicians on or before August 31, 1930.

(3) The thesis or dissertation must be in the English language, in triplicate, in typewritten or printed form, and the work upon which it is based must have been done in whole or in part in the United States or Canada.

(4) The recipient of the prize would be expected to read the essay at the next Annual Meeting of the College, after which he would be officially presented with the prize by the President.

(5) The College reserves the right to make no award of the prize if a sufficiently meritorious piece of work has not been received.

(6) The announcement of the prize winner will be made not later than two months before the Annual Meeting.

AMERICAN COLLEGE OF PHYSICIANS,
E. R. LOVELAND, *Executive Secretary,*
133-135 S. 36th Street,
Philadelphia, Pa.

BOOK REVIEWS

LA SENSITOMÉTRIE CUTANÉE. By J. SAIDMAN, Directeur-Fondateur de l'Institut d'Actinologie. Published by Gaston Doin et Cie, Editeurs, 8, Place de l'Odéon, Paris, 1930. Pages 294. Price 60 francs.

In the first section of this monograph Saidman discusses the use of his automatic sensitometer in establishing doses of actinotherapy so that a rational posology can be developed, and he points out that there are many variations in skin sensitivity. By his sensitometer the reactivity of the patient to the radiation with which he is to be treated is determined, so that all empiricism in treatment can be avoided. There follows in the second section the clinical applications of these sensitivity tests. A bibliography completes the book.

This monograph is of importance to whoever is doing specific actinotherapy.

ROENTGENOGRAPHIC TECHNIQUE: A MANUAL FOR PHYSICIANS, STUDENTS, AND TECHNICIANS. By D. A. RHINEHART, A.M., M.D., Professor of Roentgenology and Applied Anatomy, School of Medicine, University of Arkansas; Roentgenologist to St. Vincent's Infirmary, Baptist State Hospital, Missouri Pacific Hospital, and the Arkansas Children's Hospital. Published by Lea & Febiger, Philadelphia, 1930. Pp. 388. Price $5.50.

In writing this book the author has particularly kept in mind the needs of medical students in classes in roentgenology, roentgen-ray technicians, and physicians either undertaking roentgen-ray work for the first time or doing roentgenography for themselves and their colleagues.

The usual chapters on elementary electricity, X-ray physics, and roentgen-ray machines are written in a concise, practical fashion that will be appreciated by those seeking a general review of such subjects.

The author has endeavored to standardize the technic of roentgenographic exposures, and several experiments are described which enable the operator to calibrate his own machine and apply the author's technic. These experiments will also serve to impress students with the various factors concerned in X-ray exposures and the effects obtained by varying each.

That portion devoted to positions for ex-

posure is quite complete. The various technics described by numerous roentgenologists are discussed in detail, and all the standard positions are illustrated by excellent photographs alongside of which the resulting roentgenograms are reproduced. The concise anatomical description preceding the technic for each part or organ is especially *apropos* and will be helpful to non-medical operators.

This book is a distinct addition to the roentgenologic literature and fulfils the author's purpose in a most commendable manner.

PEPTIC ULCER. ANNALS OF ROENTGENOLOGY, VOLUME TEN. By JACOB BUCKSTEIN, M.D., Instructor in Gastro-intestinal Roentgenology, Cornell University Medical College; Alimentary Tract Division, Roentgen Department, Bellevue and Beth Israel Hospitals; Consultant in Gastro-enterology, U. S. Veterans Bureau, Central Islip and Rockaway Beach Hospitals; Associate Attending Gastro-enterologist, Sydenham Hospital. Introduction by HAROLD E. SANTEE, M.D., Clinical Professor of Surgery, Cornell University Medical College; Director of Surgery, Bellevue Hospital (Cornell Division). Published by Paul B. Hoeber, Inc., New York, 1930. Pages 337. Price $12.00.

The scope of this book is practically confined to gastric, duodenal, gastrojejunal, and jejunal ulcer. It is a clinical roentgenological study of 240 cases, with case histories, and contains 287 illustrations. It is divided into four sections:

I. Introduction, which deals with the early history of gastro-intestinal examinations, barium meals, stomach types, peristalsis, relation of stomach type to physical habitus, etc.

II. Gastric ulcer, including a discussion of roentgenological contributions to this subject, with a description of organic deformities, effect of ulcer on motility, relation of benign to malignant ulcer, pathology of ulcer in relation to localization, greater curvature ulcers, healing of ulcer, and technic of examination.

III. Duodenal ulcer, with a consideration of the duodenal bulb, development of roentgenology of duodenal ulcer, and technic of examination.

IV. Gastrojejunal and jejunal ulcer, with a consideration of the ulcer niche, deformity, localization of tender points, etc.

There is a serious doubt as to the pictorial quality of the original films, yet withal the book is worth adding to one's library.

ACTA RADIOLOGICA. *Supplement III, Part 1.* A report of the Second International Congress of Radiology and the proceedings of the Joint Scientific Meetings of the Congress, Stockholm, July 23 to 27, 1928. *Supplement III, Part 2.* Abstracts of communications at the Second International Congress of Radiology. *Supplement IV, Teaching and Training in Medical Radiology.* Papers delivered at Second International Congress of Radiology.

These supplements to *Acta Radiologica* report in detail the various proceedings of the Second International Congress of Radiology. Excellent reports covering these will be found in RADIOLOGY, October, 1928, XI, 347–352.

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APPENDIX (DIAGNOSIS)

Radiological Diagnosis of the Diseased Appendix. A. Orliansky. Brit. Med. Jour., Feb. 22, 1930, No. 3607, p. 330.

The appendix can be visualized radiologically in about 90 per cent of cases. Frequently it is visualized only after thorough purgation of the bowels. Two different types of fixed appendix are described: (*a*) The appendix fixed to the cecal wall; stretching of the fixed appendix through filling of the cecum causes pain; the pain subsides when the cecum empties. (*b*) The appendix with the tip only fixed to the pelvic wall; emptying, with consequent rise of the cecum, causes pain through dragging on the fixed appendix.

Spasticity of the cecum may be observed during an attack of acute appendicitis, but occasionally also in chronic disease. The dilated appendicular canal, and particularly the club-like dilatation of the distal end of the appendix, are almost certain signs of a diseased appendix.

Not much importance can be attached to tenderness of the visualized appendix in the absence of other confirmatory signs and symptoms of appendicular disease. Cecal stasis may be due to a chronic appendicitis, but, on the other hand, may be found in cases of normal appendix. In the presence of cecal stasis and chronic appendicitis, it is difficult to say which of the two is the primary, and which the secondary condition.

Appendicular stasis is suggestive of chronic appendicitis only in the presence of other confirmatory radiological signs and clinical symptoms of appendicitis. Stasis persisting after the administration of a purgative is sometimes caused by a partial, localized stenosis of the appendicular canal; the fluid barium penetrates through the narrowed lumen, but cannot be expelled after it has thickened and hardened through absorption of fluid. Appendicular stasis is sometimes seen in chronic tubo-ovarian inflammatory conditions, with or without inflammatory involvement of the appendix. The non-filling of the appendix can be interpreted as a pathological sign only in cases in which the appendix cannot be visualized after repeated purgation, each purgation being followed by a barium meal.

WALLACE D. MACKENZIE, M.D.

Roentgenographic Visualization of Appendical Perforation. José Arias Avellán. Am. Jour. Surg., February, 1930, VIII, 427.

The author reports a case with indefinite abdominal symptoms, yet giving no signs or symptoms pointing definitely to pathology in the appendix. During the course of the injection of a barium enema, the appendix was found to be large and retrocecal. When it was entirely filled, the barium was seen to escape from the distal end and to pass into the abdominal cavity. The reproductions of several films are published with this paper, graphically showing this phenomenon. Under appropriate treatment the patient recovered completely.

HOWARD P. DOUB, M.D.

BONE (DIAGNOSIS)

Radioulnar Synostosis, with Report of a Case. Edward S. Blaine. Ill. Med. Jour., March, 1930, LVII, 166.

The condition of radioulnar synostosis, or "congenital pronation," is of considerable interest. About a hundred cases have been reported in the literature.

This condition is due to a congenital fault and consists in the fusion of the upper portions of radius and ulna in a position of more or less pronation so that supination is not possible. The amount of fusion in reported cases is from one to six centimeters in length. It is a bilateral condition in about 50 per cent of the cases and occurs more frequently in males than in females. In several cases it occurred in successive generations of the family.

The X-ray report of Dr. Blaine's case is as follows: "The X-ray examination reveals a bony fusion of the radius with the ulna. The synostosis is one centimeter in length on the

left side and six centimeters on the right side. The bone texture is normal. There is asymmetry at the wrists, the right one showing a degree of posterior luxation of the ulna with a prominent styloid process. The left wrist is normal. No other bone or joint changes were found."

The writer discusses the various types and considers the embryological and phylogenetic aspects of this type of synostosis.

C. H. DeWitt, M.D.

Fractures of the Hip. C. E. Ruth and V. A. Ruth. Jour. Am. Med. Assn., Jan. 18, 1930, XCIV, 169.

At the hospital the primary diagnosis of fracture of the hip should be made with the X-ray, the film giving an accurate picture of the condition. Proper methods can be instituted to obtain and maintain reduction. Frequent checks on the position should be made with the X-ray. The authors consider fractures under six heads, roughly, in the order of their interest and difficulty of treatment. They stress the value of the X-ray in the primary diagnosis and in the subsequent treatment.

C. G. Sutherland, M.B. (Tor.)

Roentgenologically Demonstrable Deformities of the Patella Following Fracture. M. J. Madlener and H. R. Paas. Fortschr. a. d. Geb. d. Röntgenstr., January, 1930, XLI, 38.

On re-examination of thirty-one healed patellar fractures, deformities were studied which occurred as a result of traumatism, but did not belong to the arthritis deformans entity. A number of these fractures had been treated by wire sutures, and some of them conservatively without surgical interference. On roentgenologic examination in three planes, sagittally, frontally, and axially, deformities in all diameters were observed. Elongation was most common and most pronounced; broadening was not infrequent, but not so marked as elongation. Irregularities of all surfaces were quite common, partly as a result of callus formation, partly as the result of exostoses which may have occurred either following displacement of particles of periosteum, or as calcifications and bone formation in adjacent soft tissues, especially tendons and ligaments, finally becoming fused to the bone itself. Possibly the wire suture was partly responsible for some of the deformities, but it was also remarkable that the functional result practically never was impaired by the degree of patellar deformity.

H. A. Jarre, M.D.

Concerning the So-called "Osteitis Fibrosa" ("Osteodystrophia Fibrosa"). R. Kienböck. Fortschr. a. d. Geb. d. Röntgenstr., January, 1930, XLI, 34.

This short paper is a consideration of two disease entities: First, osteitis deformans Paget; second, osteitis fibrosa cystica generalisata, Engel-Recklinghausen or "generalized fibrocystic disease of the bones." Kienböck states that there is no relationship between these two disease entities, and that they can be clearly separated anatomically, as well as clinically and roentgenologically. Osteitis deformans Paget is a peculiar benign atrophic-hypertrophic dysplasia which, according to anatomic symptoms, may also be termed a sclerotic-hyperostotic osteoporosis with a complete metaplasia of the involved portions of bone. In this disease resorption and regeneration of osseous tissue are closely associated. The bones appear thickened and their normal curvatures are increased. Their surfaces appear somewhat loosened up and a new shell of apposition of bone may be seen. Fibrotic osteoid tissue may be interspersed. The affected portions of the skeleton are usually diffusely and evenly diseased. No hemorrhagic cysts occur, but occasionally there are atrophic cysts. Fractures occur but rarely, and most frequently are fissures or green-stick fractures with delayed healing and formation of large intramuscular "osteomata." Clinical symptoms are rather insignificant, considering the extent of the skeletal disease. The course

is slowly progressive though occasionally involvement of only one bone occurs. The cranium is frequently affected. Large portions of the skeleton may become involved, but always some bones remain healthy; thus the disease process may be multiple, but it never is generalized. The onset of the disease usually occurs around the fortieth year, never during adolescent age. Secondary malignant degeneration of Paget's disease was observed by Paget himself.

Osteitis fibrosa cystica generalisata also is a benign skeletal affection of exquisitely atrophic dysplasia. First, a very marked decalcification or osteoporosis occurs, with but very little regeneration of supporting new bone tissue. Much fibrotic and osteoid tissue develops, leading to a systematic fibrosis and malacia of the bone. The entire skeleton is diffusely affected. It is a generalized disease. The bones become abnormally weak and brittle, resulting, therefore, in extensive deformities and frequent fractures, with large hematomata and hemorrhagic cysts, so-called "brown tumors." As a whole, the changes show a great variety and irregularity. Clinical symptoms usually start with deformities, fractures, spontaneous ruptures. The persons affected suffer severe pain, especially under the influence of multiple fractures. Very soon they become complete invalids. In all severe cases tumor formation of the thyroid gland, arising from the epithelial bodies, takes place. Progressive and regressive stages occur quite frequently. Complete cure has been observed occasionally, resulting in relief of pain, with remaining deformities of the skeleton. The onset of the disease may occur at any age, including youth and adolescence. The female sex is commonly affected. Kienböck states that differentiation between these two disease entities is important, as therapeutic indications depend upon a correct diagnosis.

H. A. JARRE, M.D.

CHEST (DIAGNOSIS)

Calcification of the Pleura. K. Ulrich. Röntgenpraxis, March 1, 1930, II, 212.

Calcification of a thickened pleura can be shown roentgenologically fairly often. In about 1,800 chest examinations made by the author, pleural thickening and adhesions were found in 24.6 per cent. In 3.5 per cent of the latter group, calcification was demonstrable. Fluoroscopic examination alone often does not show this condition. A plate-like calcification is most frequently encountered, less so the disseminated and irregular type. Pleurisy leading to thickening and calcification dated back more than ten years in 11 of the 16 cases, the shortest time being five years. A rather long period is necessary for pleural calcification, in the author's opinion. In only one case could tuberculosis be held responsible for it. A hematothorax after injuries seemed to be the etiological factor in many instances.

H. W. HEFKE, M.D.

Chest Roentgenograms of Non-tuberculous Children Suspected of being Tuberculous. Ernst Wolff and Robert S. Stone. Jour. Am. Med. Assn., Feb. 15, 1930, XCIV, 458.

The marked confusion existing in the interpretation of the shadows in the roentgenograms of children's chests is remarked by Wolff and Stone. Twenty normal children were examined at the Institute of Child Study in Berkeley, California, as a control, and comparisons of the findings in the normal and the group studied were charted. The authors' conclusions were that a diagnosis of mediastinal glands or lung tissue cannot be based on these observations. No definite correlation was found to exist between the positive roentgen observations and the clinical history.

C. G. SUTHERLAND, M.B. (Tor.)

Roentgen Study of Apical Chest Tumors. W. F. Henderson. Am. Jour. Surg., February, 1930, VIII, 414.

These tumors are uniformly located in the apex of the chest. They have no connection with the hilum and are not of mediastinal origin, but apparently are primary endotheliomata of the pleura. They are characterized

by a lower border, very sharp and usually almost perfectly straight, with little or no tendency to invade the subjacent lung tissue, and present a picture of uniform density. The remaining portions of both lungs are usually clear. A diffuse thickening of the pleura from a previous inflammatory process might cause confusion, but usually other pleural changes make the differentiation possible. Clinically, there is severe pain in the shoulders, radiating down the arm, and there is a surprising disproportion between the magnitude of the roentgen findings and such physical signs as can be elicited. The lack of physical findings is one of the striking features in this disease and many cases are entirely unsuspected clinically. In several patients, shortly before death, the tumor exhibited a tendency to break through the lower margin and to involve the structures immediately beneath. In these cases, no evidence of any metastases elsewhere could be demonstrated. In one case, however, metastatic lesions did occur. Ewing describes these tumors as "originating in the form of multiple nodules or flat elevations, widely distributed over either the parietal or visceral pleura, or perhaps both. These nodules or plaques fuse to form a dense firm mass which covers and compresses the lung. A serofibrinous or bloody exudate accompanies the growth, which gathers in small cysts or larger collections."

Contrary to the findings of Pancoast, the author observed little or no ocular symptoms, and also his cases have been almost uniformly attended with hoarseness, advanced in certain cases to the degree of aphonia. He has seen eight cases, of which seven were in adults. All of these patients but one were of the male sex. Three case reports are presented.

HOWARD P. DOUB, M.D.

An Unusual Case of Massive Atelectasis of the Right Lung. Harry L. Baum. Laryngoscope, February, 1930, XL, 124.

The author reports a very interesting case of massive atelectasis of the right lung, in which the patient was ambulant, had no temperature, slight shortness of breath, pulse of about 100, and felt better generally than she did before the collapse occurred. X-ray films taken six months before the collapse showed evidence of slight tuberculous activity in both upper lobes. There was a history of pneumonia at the age of ten. An X-ray film taken after the collapse showed typical findings of massive atelectasis, with displacement of the heart and mediastinal structures, with over-expansion of the left lung. Bronchoscopically, stenosis of the right main bronchus was observed, starting just below the carina. About a dram of mucopurulent secretion (positive for tubercle bacilli, but not in large numbers) was aspirated. The Wassermann test was negative. There was no history of foreign body. Six months later the atelectasis was still present and the condition of the patient was unchanged.

B. C. CUSHWAY, M.D.

Comparative Findings of Roentgen Examination of the Lungs, and Autopsy. Erich Saupe. Röntgenpraxis, March 1, 1930, II, 193.

Close co-operation between pathologist, roentgenologist, and clinician allowed the author to compare roentgenograms of the chest with the autopsy findings. The roentgenologist should hesitate to make too definite statements about the type of tuberculosis, whether productive or exudative. Even the pathologist can often decide it only with the microscope. Soft shadows in the apices do not always indicate an active process; they often represent small atelectatic-cirrhotic areas, or small pleural plaques. The roentgenological demonstration of a thin interlobar shadow must not necessarily mean an interlobar pleurisy. A normal interlobar pleura may be shown, if the conditions are correct. A localized emphysema of the lung may occasionally make it difficult to diagnose cavities, some of the emphysematous blebs reaching the size of a cherry. Bronchiectases were found more often during autopsy than in the roentgen films. Their diagnosis is not made frequently enough by the radiologist in the author's opinion. Bronchography may be of help in doubtful cases.

The roentgen picture of chronic passive congestion, although typical in many instances, may sometimes be very confusing. Complicating bronchopneumonia or multiple small infarcts are often overlooked. Small bronchial carcinomas are very hard to demonstrate, and sometimes only bronchography will show them. The signs of bronchostenosis can be elicited occasionally by forced and fast inspiration. One must remember that some chronic pneumonia accompanies all cases of bronchus and lung carcinoma. Very small lung tumors, often invisible themselves, may present very large mediastinal metastases, which, however, are usually unilateral, in distinction from the primary mediastinal tumors. A trial of radiotherapy may be the only means of making a differential diagnosis. It is very difficult to id carcinomatous involvement of the pleura. angential examination in different levels is ften necessary. Many other chest conditions e described, comparing the findings of the entgen examination with the autopsy, and pecially pointing out the possibilities of error id the difficulties of differential diagnosis.

H. W. HEFKE, M.D.

Atelectatic Bronchiectasis. A. J. Scott Pinchin and H. V. Morlock. Brit. Med. Jour., Jan. 4, 1930, No. 3600, p. 12.

The authors present cases showing, clinically, a cough and the raising of much sputum; and radiologically, a triangular shadow at the base of the lung, one side of which rests on the diaphragm and one along the mediastinum. They concur with the work of Singer and Graham in demonstrating bronchiectasis in these cases by the injection of lipiodol. The shadow of an atelectatic lobe or part of a lobe may be similar to the triangular shadow now under discussion. The clearing up of a collapsed area of lung is dependent on the free mobility of the chest and diaphragm, and occurs least readily in the location under discussion.

It is concluded that the most common lesion with which this shadow is associated, is bronchiectasis. It is agreed with Wallgreen and Sergent that the presence of this shadow should always raise the suspicion of a bronchiectasis unless other clinical evidence is forthcoming to clinch the diagnosis of a mediastinal effusion. It is a matter for speculation how much influence local areas of collapse exert in the etiology of bronchiectasis.

WALLACE D. MACKENZIE, M.D.

GALL BLADDER (NORMAL AND PATHOLOGICAL)

The X-ray in the Differential Diagnosis of Bile Tract Disease. D. S. Beilin. Ill. Med. Jour., January, 1930, LVII, 45.

In examining the gall bladder following dye administration, we should remember that: "The gall bladder, liver, duodenum, stomach, and pancreas are embryologically, anatomically, physiologically, and pathologically closely related" (MacCarty). In addition to the findings possible from cholecystography, in which the author prefers the oral method, a roentgenological examination can throw some light on several other conditions. Abnormalities in size, position, and form of the liver, abscess of the liver, sub-diaphragmatic abscess, cancer of the liver, and syphilis of the liver often give fairly characteristic findings. Carcinoma of the stomach and head of the pancreas should always be considered in bile tract disease. In selected cases, pneumoperitoneum has a definite place.

W. W. WATKINS, M.D.

The Graham Test. Edward L. Young, Jr. New Eng. Jour. Med., Jan. 30, 1930, CCII, 219.

Two years ago this author reported end-results in a series of cases of cholecystitis, which showed 63 per cent cured by operation. The present study was made to ascertain whether the use of the Graham test has helped the accuracy of diagnosis. The study includes 144 cases, 84 of which were operated upon. Of the positive diagnoses based on the dye test, 88 per cent were correct for bile tract disease. Where the test was negative, 68 per cent were correct. The figures seem to show a considerable chance for error in the Graham test, which we must always remember is a test

for function, therefore, the clinical evidence should always take precedence. The use of the test increases the accuracy of the diagnosis.

W. W. Watkins, M.D.

Oral Cholecystography in the Study of the Digestive Tract. Arrigo Foà. Minerva Med., Dec. 8, 1929, IX, Pt 2, p. 909.

Systematic researches on one hundred cases of normal individuals and in morbid conditions of the gall bladder have convinced the author that cholecystography by the oral method involves so few sources of error that its routine use is indicated. Cholecystography by the intravenous method is advised only in the few cases in which, without apparent pathological cause, the oral method does not succeed.

L. Marinelli.

GASTRO-INTESTINAL TRACT (DIAGNOSIS)

Diverticulitis, with Particular Reference to its Diagnosis by Radiology. W. H. Rowden. Brit. Med. Jour., March 1, 1930, No. 3608, p. 381.

The first step toward diverticulitis is the development of a condition of diverticulosis. That diverticulosis is not a congenital abnormality is concluded from the rarity with which the condition is found in young persons. The condition of diverticulosis itself is not a disease. It is only when inflammatory changes occur in or around the diverticula that symptoms and signs of disease are manifested.

A complete and definite diagnosis of diverticulitis can be made only by means of exploratory laparotomy and microscopical examination of an excised portion of the affected bowel, or by means of X-ray examination. As the treatment is chiefly medical, X-ray examination is the method of choice.

An examination by means of the opaque meal will give information as to the presence of diverticulosis, but it will not, as a general rule, provide evidence as to whether or not there is an accompanying diverticulitis. For the demonstration of diverticulitis an opaque enema is preferable. The two methods may be satisfactorily combined. It is of the utmost importance that roentgenographs should be taken with the patient in the right and left oblique positions, in addition to the usual one taken in the postero-anterior position.

The earliest change in the appearance of the bowel in diverticulitis is an alteration in the haustration. The haustral indentations, instead of being placed opposite one another, alternate on each aspect of the bowel; secondary smaller indentations also make their appearance; the indentations are regular in outline. This is the stage of irritation. In the next stage the haustral indentations, in addition to being spaced irregularly, become irregular in outline, producing an irregular V-shaped or W-shaped appearance of the bowel. This is the stage of thickening of the bowel wall. The third stage is that of the filling defect. The filling defect is produced by encroachment upon the lumen of the bowel by the thickened wall, resulting in a narrowing, which, if the condition is untreated, will eventually lead to complete obstruction. Frequently the three stages can be seen in the same patient, involving different parts of the bowel.

With regard to the differential diagnosis, malignant disease comes first. The distinguishing points are:

1. Diverticulitis is associated with the presence of diverticula in the neighborhood of the deformity in the outline of the bowel; in carcinoma, diverticula, as a rule, are not present.

2. Diverticulitis produces a deformity which is characteristic of the disease. The deformity produced by a growth varies according to whether the growth is of the ulcerating, papillomatous, or encircling-ring type.

3. Diverticulitis usually involves a considerable length of the bowel, whereas the length of the bowel involved by carcinoma is short.

Diverticulitis is differentiated from ulcerative colitis by the fact that in the latter there

20 to 70 mm. with his technic. He recommends that the Grenz-ray therapeutist, like others, master the technic and physics of this method, and not be careless because the danger is less. He believes that general therapy has great value, just as has local treatment. A profound effect is exerted on the entire organism, the vegetative system, and the ductless glands alone and in combination. The general reactions are indicated by loss of appetite, weariness, and exhaustion. The local reaction is cutaneous through increase of the pathological process. As secondary effects, he often observed regulation of formerly somewhat irregular menses, general increase of vitality of the individual indicating a profound constitutional effect.

He then follows with the special indications in skin diseases, giving the dosage required in all of the various skin diseases which are amenable to this form of treatment.

HOWARD P. DOUB, M.D.

Determination of the Size of Fields in Borderline Ray Therapy. R. Spiethoff and Heinz Berger. Strahlentherapie, 1930, XXXV, 90.

The surface intensity of radiation emitted by a low voltage tube (9 K.V., 10 ma.) was determined for 2.5, 5, and 10 cm. F.S.D. A simple method is described which permits the determination of a number of fields necessary for the homogeneous exposure of certain skin areas. The article is well illustrated, demonstrating the procedure.

E. A. POHLE, M.D., PH.D.

General Considerations in Borderline-ray Therapy. G. Schulte. Strahlentherapie, 1929, XXXIV, 403.

Experience with Borderline Rays in Skin Diseases. Willy Gertz. Strahlentherapie, 1929, XXXIV, 406.

In the first of these two articles, the present status of borderline-ray therapy is briefly discussed. The author believes that in certain cases it is a welcome addition to our therapeutic agents. On the other hand, this type of therapy will not replace the usual roentgen rays.

Gertz states that the output of the apparatus and tubes must be checked carefully. A potential of 10 K.V. has proved, in his experience, to be sufficient for all treatment purposes. He found that different tubes vary as much as 40, 57, 76, 87.6, and 78 r per minute in output. The Lindemann window "ages" and does not transmit as well as when new. With a Küstner instrument, he found that 1,380 r produced an average erythema seventy-two hours after exposure. In eczema, he recommends from 250 r to 300 r, which may be repeated after eight days; in chronic types, as much as 550 r to 1,000 r; the interval must be from two to three weeks. In psoriasis, it is difficult to recommend definite doses; they fluctuate between 500 r and 1,000 r, according to the degree of hyperkeratosis. Before the X-ray exposure, ultra-violet radiation is usually applied. In lupus vulgaris, 1,400 r are given, repeated after four days until a total dose of 5,600 r has been reached. This treatment is combined with ultra-violet exposure and irradiation by ordinary roentgen rays in small doses, filtered through 4 mm. of aluminum. In acne vulgaris and rosacea, borderline rays are not recommended. In eczema of the eyelids, the author prefers borderline rays because he has never observed epilation in his cases. In patients whose skin is saturated for filtered roentgen rays, borderline rays can sometimes be used to advantage without fearing serious injuries to the skin.

E. A. POHLE, M.D., PH.D.

HEART AND VASCULAR SYSTEM (DIAGNOSIS)

Regarding a New Principle for the Determination of the Size of the Heart, and its Practical Applications. Chichio Tamiya. Fortschr. a. d. Geb. d. Röntgenstr., January, 1930, XLI, 62.

The author has constructed a new so-called bi-cathode tube which creates two beams of roentgen rays of diametrically opposite direc-

tions. One of these beams is used for fluoroscopy and orthodiagraphic focussing, according to Dr. Groedel. The second beam, conducted through a system of diaphragms, writes the contours which are seen and focussed fluoroscopically onto a film whenever a shielding window is opened. Both foci of this bi-cathode tube may be energized by one machine with four-tube-valve rectification, alternating phases of the current being conducted to the two anodes by suitable wiring, so that they receive alternating impulses. The bi-cathode tube is suitable for any other kind of roentgenologic work. It seems that this construction is quite original and convenient.

H. A. JARRE, M.D.

The Roentgen Findings in a Case of Primary Heart Sarcoma. Hans Fetzer. Röntgenpraxis, January, 1930, II, 23.

A case of primary heart sarcoma is described, with roentgen findings and autopsy report. The only abnormality in the heart shadow was a very definite bulge in the region of the pulmonary arch. There were definite areas of metastases in the lungs. The heart was not considered to be the seat of the primary sarcoma, either roentgenologically or clinically: only the autopsy cleared up the rather indefinite X-ray findings in the heart. It is extremely difficult to make a differential diagnosis from heart or pericardial diverticulum. Only the metastatic areas in the lung can lead one to suspect a primary malignant tumor of the heart, if combined with an unusual configuration of the heart shadow.

H. W. HEFKE, M.D.

LIGHT THERAPY

Our Experience with the Carbon Arc Light in Diseases of the Throat, Nose, and Ear. G. Osterwald. Strahlentherapie, 1930, XXXV, 523.

The author has used a carbon arc lamp in the Eye, Ear, Nose, and Throat Clinic in the University of Berlin, particularly in the treatment of tuberculosis of the upper air passages. He presents the statistics of 72 males suffering from tuberculosis of the larynx. Sixty-four could be used in the statistics, 35 were favorable cases in the beginning, and 29 were advanced cases. Of the 35 patients, two died, two grew worse, three showed no improvement, and 28 were definitely improved. Of the 29 unfavorable, nine died, five grew worse, seven were not improved, while eight were improved. That means that in early cases, 80 per cent responded well to the treatment, while only 27 per cent of the advanced cases could be influenced. Of 35 women suffering from the same disease, 29 could be followed up, 16 were early cases, and 13 were advanced cases. Of the early cases, one died from carcinoma of the stomach, one grew worse, and 14 were improved. Of the 13 advanced cases, two died, two grew worse, five remained unchanged, and four showed improvement. This corresponds to 87 per cent improvement in early cases and 30 per cent improvement in advanced cases. The results of the treatment of lupus were also encouraging.

E. A. POHLE, M.D., PH.D.

The Effect of Light Rays on the Alexin in the Blood Serum. I.—The Effect of Ultra-violet Rays. O. Huntemüller. Strahlentherapie, 1930, XXXV, 489.

In normal adults who were exposed to the spectrum of a Jesionek lamp (quartz mercury vapor lamp), the alexins were found to be increased, sometimes as high as three times that of the pre-treatment level. This effect was much less in dark persons and also in frequently exposed persons whose skin had become pigmented. Further studies are under way as to the effect of other regions of the light spectrum.

E. A. POHLE, M.D., PH.D.

Jesionek's "Lightbiology": A Pioneer Work Published in 1910. C. Dorno. Strahlentherapie, 1930, XXXV, 22.

The author discusses each chapter of Jesionek's book on Lightbiology, followed by a review of the literature up to date showing the

development of this interesting branch of medicine. It shows how stimulating the publication of Jesionek has been toward further investigations. The extensive bibliography offers numerous references concerning the subject.

E. A. POHLE, M.D., PH.D.

Contribution to the Measuring Methods in Light Therapy. F. Bödecker. Strahlentherapie, 1930, XXXV, 549.

In 1912, Meyer and Bering published a chemical method for the calibration of the quartz mercury vapor lamp. It is based on the titration of iodin freed by the ultra-violet rays in a KJ-H_2SO_4 solution. A comparison of this test with the photo-electric cell method shows fair agreement between the two methods.

E. A. POHLE, M.D., PH.D.

Tissue Metabolism and Radiant Energy. Werner Kollath. Strahlentherapie, 1930, XXXV, 444.

The author studied the antagonistic effect of light of short and long wave length on the oxidation-reduction-potential in vital stained surviving cells. The details of the experimental method must be looked up in the original.

In beriberi pigeons, the muscles were stained blue following intraperitoneal injection of an alkaline methylene blue solution. Normal pigeons and fasting pigeons did not present this phenomenon. It appears that the reducing power of the tissue is decreased in beriberi pigeons, but increased in fasting pigeons. The oxidation power shows the inverse behavior. Microscopic examinations of the air sacs in the peritoneal cavity of pigeons injected with methylene blue revealed a difference in the histologic structure of the epithelium, depending upon the time interval between death of the animals and injection. Under the influence of a carbon arc light, the stained air sacs were discolored very quickly (reduction of the methylene blue to methylene white). The effective radiation belonged to the ranges of 5,330 Å. – 6,500 Å., and 7,600 Å. – 12,500 Å. Since the discoloration took place also without exposure to light but after several hours instead of within a few seconds, it is concluded that the light accelerates a normal process. Cells which had been discolored by this light exposure showed a slight oxidation if they were exposed to light rays of short wave length. Red blood corpuscles with an unstained nucleus oxidized methylene white following exposure to the same light which reduced methylene blue. Carbon arc light without heat rays had the same effect. It is assumed that the point of attack of the rays is in the ferment discovered by Warburg, as far as the oxidation is concerned. For the reducing effect, there must exist another substance with opposite electrical charge. The stained oxidized phase, which has very few electrons, corresponds to the positive pole, and the discolored and reduced phase, rich in electrons, corresponds to the negative pole of the potential.

The relations of these observations to certain diseases are then discussed.

E. A. POHLE, M.D., PH.D.

LIPIODOL INJECTIONS

The Present Status of Hysterosalpingography: With a Review of the Literature and a Report of 512 Personal Cases. E. R. Witwer, H. P. Cushman, and T. Leucutia. Am. Jour. Roentgenol. and Rad. Ther., February, 1930, XXIII, 125.

The authors have made an extensive review of the literature on hysterosalpingography and present their diagnostic findings in a profusely illustrated article. In 512 cases examined by lipiodol injections, the only accident observed was a single case of ruptured tube, which was found at operation the following day, although, meanwhile, the patient had suffered no symptoms as a result of the rupture. Contra-indications to the procedure are: Recent hemorrhage, inflammatory conditions not completely quiescent, active infection or malignancies of the cervix, previous intra-uterine interventions, ectopic gestations, or uterine gestation where therapeutic abortion is not indicated, infected

cervical or uterine polyps, and fever. The preferred time for injection is from 8 to 10 days following menstruation. The "closed cervix" method is utilized but it has not been found necessary or entirely satisfactory to use a manometer; however, care must be exercised not to increase the pressure beyond the accepted safe limits of from 200 to 240 mm. mercury. The method has been proven to have great diagnostic value in anomalies of the genital tract, in tubal affections producing sterility, in selected cases of early pregnancy where therapeutic abortion is indicated, or where a differential diagnosis is essential, in non-malignant uterine tumors, and in extra-uterine pelvic tumors.

J. E. Habbe, M.D.

MEASUREMENT OF RADIATION

Comparative Measurements with the Küstner Instrument, the Martius Ionometer, and the Sabouraud-Noiré Tablet, for Dosimetry in Superficial Therapy. Martin Schubert. Strahlentherapie, 1930, XXXV, 553.

The Sabourand-Noiré Tablet was compared with two ionization instruments in a beam of roentgen rays produced at 110 K.V., no filter, 0.5 to 1.0 and 2.0 mm. aluminum. The corresponding values for erythemas of the same degree were found to be at 650 r-, 624 r-, 684 r- and 667 r-units. There was evidently no dependence of the wave length on the erythema reaction within the range examined. The author feels that the Sabouraud-Noiré method can be used in superficial therapy in connection with a sphere gap However, for accurate dosage, an ionization instrument with a chamber as independent of the wave length as possible, is preferable

F. A. Pohle, M.D., Ph.D.

Stereoroentgenometry: A Method for Mensuration by Means of the Roentgen Ray. Clayton R. Johnson. Am. Jour. Surg., January, 1930, VIII, 151.

This paper concerns a process for determining the solid dimensions of a radiopaque object from its stereoscopic roentgenograms, applicable to all those conditions wherein the knowledge of solid dimensions may be of value in diagnosis. This method is somewhat similar to that described by Sir James Mackenzie Davidson, in 1898, for localization of foreign bodies. It is quite accurate for pelvimetry as well. The author goes into great detail in describing all the steps in this method. It is impossible, however, to abstract his paper in an intelligible way without reproducing the illustrations referred to in the text. It is well worth detailed study by anyone interested in pelvimetry or the localization of foreign bodies.

Howard P. Doub, M.D.

PAGET'S DISEASE

Osteoporosis Circumscripta Schüller—A Rare but Typical Manifestation of Paget's Disease. Konrad Weiss. Fortschr. a. d. Geb. d. Röntgenstr., January, 1930, XLI, 8.

Schüller, in 1929, published a series of cases showing, as characteristic changes, extensive, sharply demarcated areas of resorption, involving large portions of the cranial vault. While the author is uncertain about the etiology of these changes, he feels inclined to consider them as manifestations of Paget's disease in other portions of the skeleton, thus confirming Schüller's opinion about the etiology of these cranial affections. One case with rather extensive cranial pathology, also reveals, as a single clinical sign, marked tympany on percussion over the affected portion of the cranial vault, which previously was described as a symptom of Paget's disease by Gross, Mayer, and Vogl. Discussing the etiology and development of osteoporosis circumscripta and other manifestations of Paget's disease, the opinion is stressed that osteoporosis apparently is a developmental stage of Paget's disease, as Eisler, in 1922, reported an instance where the typical appearance of Paget's disease succeeded the typical picture of osteoporosis circumscripta though in a long bone. Paget's manifestations in the pelvis also, according to Kienböck, not infrequently are found as extensive areas of re-

sorption of lime salts, entirely resembling this type of osteoporosis. Observations on these two cases lead to the conclusion that osteoporosis circumscripta and Paget's disease are not merely related diseases, but that osteoporosis circumscripta is a rarely occurring typical manifestation of osteitis deformans.

H. A. JARRE, M.D.

RADIUM

The Use of Radium in the Treatment of Rectal Carcinoma. J. P. Lockhart-Mummery. Brit. Med. Jour., Jan. 25, 1930, No. 3603, p. 139.

Radium may be used in three ways in the treatment of rectal carcinoma: (1) As an adjunct to excision, thereby enabling a less serious operation to be performed; (2) in the treatment of cases that are surgically inoperable; (3) as a substitute for the operation of excision. At the present day it is generally agreed by surgeons that the only justifiable treatment for even an early case of carcinoma of the rectum is complete removal of the rectum and surrounding tissues, with the establishment of a permanent colostomy opening. With this method the proportion of cures (based on a five years' survival) is now over 50 per cent. This operation, however, is a mutilating one, and the technic herein described, whereby, with the suitable use of radium, the patient is saved a permanent colostomy, will, if the proportion of cures still remains high, be a great advance over present methods.

(a) As an adjunct to excision:—The cases treated so far have been very early growths in the middle or lower part of the rectum on the posterior wall. The author's technic is as follows: (1) Removing coccyx and necessary portion of sacrum and freeing rectum; (2) local removal of the growth, together with a half-inch margin of healthy tissue; (3) closure of rectal wound by transverse sutures and sewing of muscles back into place; (4) placing of radium needles in the mesorectum, along the line of lymphatic spread on each side of the rectum, and in the tissues in the immediate neighborhood; (5) closure of the back wound except for a small drain, the threads attached to the radium needles being left inside the wound; (6) drainage of the rectum by a large tube through the rectum; (7) at the end of a week, the re-opening of the wound and the removal of the needles, in such a way that free drainage is provided. Cases thus treated have done well to date, function being perfectly restored and the bowels acting in a normal manner. If the results in these cases are good as regards recurrence, which time alone will show, then we have a method in suitable cases which will enable a colostomy to be dispensed with, and a normally functioning rectum to be left.

(b) As a substitute for excision:—The results of radium treatment at the present time do not justify it being used in place of excision in operable cases, but the best results that the writer has seen have been in cases of epithelioma of the anus in elderly persons.

(c) In inoperable cases:—The technic is still in the experimental stage. Most of the cases treated have been in this category. The tendency has been towards smaller doses spread over a longer period of time, with the aim of decreasing the severity of the local reaction. It has also been found an advantage to increase the total dosage up to 6,000 mg.-hrs., and at the same time increase the screening. The author's method of exposure is similar to that outlined under "(a)," the needles being placed roughly parallel to the lumen of the bowel to avoid perforation and unnecessary infection. If the growth is on the anterior wall of the rectum it is barraged from the front by exposing the rectum by an incision across the perineum. In all cases the abdomen has to be opened and needles, or preferably radon seeds, inserted into the upper part of the mesocolon and the areas on each side of it. All the early cases developed a plastic peritonitis due to the radium, which has to be drained.

The chief difficulties are gaining access to the growth, and sepsis.

W. D. MACKENZIE, M.D.

Radium Teletherapy: Note on the Apparatus at Present in Use at the Westminster Hospital with Four Grams of Radium. Francis Rock Carling. Brit. Med. Jour., Feb. 8, 1930, No. 3605, p. 232.

This apparatus was designed to meet the problem of making the most effective though economical use of the radium, and at the same time to afford proper protection of all persons, except those actually under treatment, from the emanations. The radium is used in a "bomb," being placed inside a lead shield in five containers. The apparatus is constructed so that two patients may be treated simultaneously, one above and one below the lead shield containing the radium, while in the horizontal plane, the average protection provided amounts to some six inches of lead. When not in use the radium containers are withdrawn radially from the cylindrical hollow center until they are buried in the lead mass. The separation into containers reduces the skin intensity and flattens the isodose lines, while only slightly reducing the dose at a depth. The dimensions of the "radiant beam" can be controlled by a system of cylindrical lead plugs. The screenage, amounting to the equivalent of just over 1 mm. of platinum, consists of monel metal, brass, aluminum, and wood.

W. D. MACKENZIE, M.D.

SKIN (GENERAL)

Investigations Concerning the Heat Distribution in the Skin Following Intense Exposure to Visible Light. Svend Lomholt. Strahlentherapie, 1930, XXXV, 324.

The author reports the results of his investigations of the heat distribution in the skin following exposure to carbon arc light, filtered in such a manner that only radiation between 5,700 Å. and 9,000 Å. were transmitted. The reflection, which was determined by direct calorimetry, amounted to about 30 per cent. About 9.5 per cent is due to simple reflection while the balance is due to dispersion. The absorption of dead skin and of living skin is of the ratio of 1.4:1; in other words, dead skin absorbs more than living skin. The skin of man, rabbits, and rats showed nearly id tical behavior. The heat distribution in skin following exposures up to toleration determined by means of small colorless tol thermometers which were embedded in s folds. Behind the skin layers of 1.1, 1.4, 5.0 mm. thickness, the temperatures were 4 40.0, and 37.7 degrees Centigrade, respectiv The heat conductivity of dead skin was fo to be much less than that of water. The sorption of blood in a layer of 0.3 mm. thi ness amounted to about 55 per cent. analysis of a piece of irradiated skin shov that the blood content amounted to only per cent of the total weight of the specim The author concludes from this that the r jor part of the light is not absorbed by blood, but by other components of the sl From his observations, it seems improba that even the most intensive exposure to c bon arc light will increase the body tempe ture above that of the highest fever.

E. A. POHLE, M.D., PH.D

On the Dependence of Pigment Forn tion on the Wave Length of the Radiati Erich Uhlmann. Strahlentherapie, 19 XXXV, 361.

The author exposed human skin to mo chromatic radiation, obtained by means o quartz spectrograph. He could confirm work of Hausser and Vahle, and verified erythema maxima at 2,970 Å., 3,030 Å., a at 2,480 Å., and 2,540 Å. The relation tween pigmentation and wave length was so simple. There was a maximum at 2,480 and 2,540 Å., also at 3,130 Å. and 3,1 Å. The latter two, however, were not so p nounced and could be observed only in cert cases. This observation also explains well known difference in the pigmentati produced by the quartz mercury vapor lar and by the sun.

E. A. POHLE, M.D., PH.D.

SKIN (THERAPY)

Roentgen Sterilization in Impetigo H petiformis. O. Grütz. Strahlentherap 1930, XXXV, 501.

The author relates the history of a wom

thirty-five years of age who developed a skin disease about one year after her first pregnancy. The symptoms recurred and the disease was diagnosed as impetigo herpetiformis. Symptomatic treatment improved the condition, but, following the first menstruation after childbirth, a new and very severe recurrence appeared. Since the condition was always worse at the time of menstruation, a temporary sterilization was carried out. This was followed by amenorrhea for a period of about six months, during which time the skin eruptions did not reappear. The first menstruation occurred after seven months and there was a prompt reappearance of the impetigo. The calcium in the blood was found to be d creased to about 50 per cent of the normal value, while the basal metabolic rate was increased to 131 per cent. The woman has decided to undergo permanent sterilization if the isease recurs again. The author then disusses the possible theory for explaining this servation.

E. A. POHLE, M.D., PH.D.

Our Experience Concerning Dosage and Filtration in Roentgen Therapy of Skin Diseases. E. Galewsky and Karl Linser. Strahlentherapie, 1930, XXXV, 561.

The authors recommend the use of small doses of lightly filtered roentgen rays in the treatment of skin diseases. In psoriasis, eczema of the lids and lips, and in pruritus ani, this is particularly essential. Not only are late reactions very improbable but the results are, in the writers' experience, much better.

E. A. POHLE, M.D., PH.D.

Treatment of Skin Tuberculosis with Trypaflavin (Neutral Acriflavine) and the Quartz Mercury Vapor Lamp. W. Frieboes. Strahlentherapie, 1930, XXXV, 528.

The author describes the treatment of tuberculosis of the skin as practised in his clinic. He first applies 5 per cent pyrogallol ointment and then exposes the lesions to the quartz mercury vapor lamp. Shortly before the exposure, 5 c.c. to 10 c.c. of a 1 per cent trypaflavin solution is given intravenously. Up to thirty and forty injections were given in a single case without any serious consequences. He believes that the cosmetic results are much better with this combined treatment. A diet low in sodium chloride is also recommended.

E. A. POHLE, M.D., PH.D.

X-ray Treatment of the Commoner Microbic Diseases of the Skin. J. B. Higgins. Brit. Med. Jour., Dec. 21, 1929, No. 5598, p. 1152.

There are many explanations as to the biological changes produced in the individual skin cells exposed to X-ray. Among these the foremost are the theories of Hertwig, Packard, Holzknecht and Caspari. The fact remains, however, that small doses of X-ray have a decidedly stimulating effect on certain skin diseases, and at the present day X-ray ranks as one of the most reliable factors in their treatment. The greater sensitivity of diseased cells, which is always present, permits the administration of an effective dose, but, in the presence of hyperemia accompanying the pathological condition, we have the added factor of a skin which has become definitely hypersensitive, thus cutting down the margin of safety between stimulation of the affected cells and injury to the surrounding hyperemic skin. The apparatus used at the Manchester Skin Hospital consists of a 16-inch coil. The rays are emitted from a Cooldge tube and are of a quality produced by a kilovoltage of 120 and a milliamperage of 3½, *i.e.*, soft and medium rays at an equivalent spark gap of 6½ inches. Under these conditions an erythema dose (Sabouraud pastille) can be produced in approximately two minutes at an anticathode distance of 8 inches.

Acne vulgaris (including acne indurata): Dosage consists of a preliminary course of three or four half skin doses, unfiltered, and administered with intervals of seven days between doses. Following this a similar course is given, but a filter of 0.5 mm. of aluminum is used. An average of five to six skin doses in

each case is required to produce a cure. It would appear that the curative effects of X-rays on acne depend not so much on the degree of filtration, or quality of the rays employed, as on the total quantity of the latter which are absorbed by the skin. The actual amount of absorption required to produce a cure depends on: (*a*) the type of skin to be treated; (*b*) the interval between the treatments. The shorter the interval between treatments, the greater the cumulative effects of the rays. Most cases can be cured in approximately seven or eight weeks, with no ill effects. Any inhibitory effect on the growth of the bacillus which might occur may be regarded as negligible.

Sycosis vulgaris or sycosis pyogenica: Here hyperemia is almost invariably associated, so one is dealing with a hypersensitive skin. Certain general principles must be observed if one is to avoid disaster. First, an acutely inflamed skin should on no account be treated by X-ray until some successful effort has been made by other means to reduce the hyperemia.

Three methods of treatment are open to the radiologist: (1) Epilation of the beard; (2) stimulation of the affected cells; (3) a combination of these methods. In very hyperemic cases it is best to administer small stimulating doses (one-third skin dose at weekly intervals). The greatest success from the radiological standpoint is obtained in those cases which show practically no hyperemia. The dosage may be carried to the point of epilation, which appears to be the ideal method of treatment. It has been the author's experience that, while the mild stimulation of the infected beard produces marked improvement in most cases, a complete cure cannot be hoped for through the medium of X-rays alone as long as infected hairs remain. Sycosis is treated, except in a few cases, without the use of filters. It would be reasonable to assume that the use of a thin filter would allow the administration of rather larger dosage, but too heavy filtering is liable to result in unpleasant consequences, such as temporary paralysis and swelling of the salivary glands. The method of treatment by super-soft rays (G. Bucky and J. J. Eller) which gives good results in sycosis, paronychia, and carbuncles, is as yet in its infancy.

W. D. MACKENZIE, M.D.

Dermatoscopic Findings in Normal Skin Following Application of the Water-cooled Quartz Mercury Vapor Lamp under Compression. Max Popper. Strahlentherapie, 1930, XXXV, 539.

The author studied changes in the skin following exposure to the water-cooled type of quartz mercury vapor lamp and to the Finsen lamp, with the dermatoscope. He found that the reactions to the lights were very similar in many respects. However, the quartz mercury vapor lamp had a more superficial effect, with injuries to the epidermis, while, following the Finsen treatment, a direct effect of the radiation on the epidermis and on the cutis could be observed. The reactions in the cutis appeared to be increased following the exposure to the Finsen light; in cases of irradiation with a quartz mercury vapor lamp, they appeared to a much lesser degree and only after the inflammatory reaction had subsided.

E. A. POHLE, M.D., PH.D.

THE SKULL

Encephalographic Visualization of the Cisternæ at the Base of the Skull and Their Diagnostic Evaluation. K. Goette. Fortschr. a. d. Geb. d. Röntgenstr., January, 1930, XLI, 1.

Exact knowledge of the subarachnoid spaces at the base of the brain is of considerable diagnostic importance, because pathologic changes can be utilized for the localization of cerebral changes, especially in the posterior fossa. To study these spaces, human brains were injected or painted with contrast media, and, subsequently, roentgenograms made which were compared with encephalograms. The longitudinal fissures to both sides of the falx, the sulcus corporis callosi and cinguli, the cisternæ ambiens, interpeduncularis and the Sylvian fissure, are fairly well known. Particular attention in these studies

was paid to the so-called choreoid fissure, which is a space located between the posterior pole of the thalamus, especially the pulvinar, and the adjacent portion of the posterior and temporal lobes next to the fornix. This space continues upward into the velum triangulare; while it is usually short and well closed off by fusion of both leaves of the pia-arachnoid, occasionally it may be found extending far underneath the corpus callosum. Photographs of several injected specimens and encephalograms, some of them purposely obtained with slight cranial tilting, illustrate the exact location of this fissure and its relation to the other basilar cisternæ. Two cases are recorded in which the exact study of these fissures led to correct diagnoses, one in which a walnut-sized glioma in the left temporal lobe, posterior portion, was localized; a second one in which hemorrhage into the internal capsule was diagnosed.

H. A. JARRE, M.D.

Stereo-projection of the Skull. Werner Teschendorf. Fortschr. a. d. Geb. d. Röntgenstr., January, 1930, XLI, 17.

Optimal roentgen stereoscopy requires special projections different from the standard projections commonly in use. Oblique projections are especially advantageous because the stereoscopic image will appear the more plastic, the more lines are combined to the visual impression of planes. When the axis of the radiating beam and its incidence upon the object is marked, any projection of the cranial structures may be characterized. The author is using a cap which contains three tapes equipped with opaque markers, placed at one centimeter distance. One of these tapes surrounds the base of the skull; a second one is placed along the sagittal suture, and a third one across the calvarium from one auricular meatus to the other. A chart added to this paper shows a number of oblique or semi-oblique positions, employed for advantageous stereoscopic visualization of such structures as the optical canal, the sella turcica, the mastoid process and auricular meatus, the petrous portion of the temporal bone (this latter in three different projections), the base of the skull, including the foramen magnum, the occipital condyles and the foramina transversalia, the maxillary antrum, and the frontal and sphenoid sinuses. A number of stereoscopic roentgenograms which may be viewed with a small hand-stereoscope, illustrate the advantages of this method.

H. A. JARRE, M.D.

Roentgen Rays and So-called Hemato-encephalic Barrier. B. Mogilnitzki and L. Podljaschuk. Fortschr. a. d. Geb. d. Röntgenstr., January, 1930, XLI, 66.

The finest method of microscopical technic revealed no alteration in the nervous elements of the cerebro-spinal system upon roentgen irradiation. It was anticipated, however, that molecular pathologic changes might occur with a disturbance in the equilibrium of colloids. Changes due to irradiation could be found in the mesenchymal elements of the central nervous system (proliferation of vascular endothelium), but such changes were not constant and varied widely in degree with different individuals. Using the methods of vital staining with trypan blue and iron, it was found that a single irradiation of the skull of rabbits and young dogs would change the usual reaction of the mesenchymal elements, and that the repeated irradiation with moderate doses could produce physico-chemical changes besides morphologic pathology. These changes are irregularly distributed throughout the cerebrum. It was concluded that the so-called hemato-encephalic barrier is morphologically represented by the cerebral blood vessels, capillaries, and also by the mesoglia.

H. A. JARRE, M.D.

THE SPINE (DIAGNOSIS)

The Calcification of Intervertebral Disks and its Clinical Significance. Th. Rövekamp. Röntgenpraxis, Feb. 15, 1930, II, 186.

The author describes the clinical and roentgenological findings of calcified intervertebral disks. Definite pain over the affected area, ra-

diating towards the legs, decreased motility, the history being one of long standing, make this symptom-complex a rather definite one. The etiology is uncertain and therapeutic means are usually of no avail.

H. W. Hepke, M.D.

A Clincal Report of Nineteen Cases of Fractured Transverse Processes Producing Symptoms Simulating those Referable to the Kidneys. I. S. Trostler. Ill. Med. Jour., March, 1930, LVII, 192.

In the words of the author: "Fractures of the transverse processes of the lumbar vertebræ are not rare, but a series of nineteen cases which gave symptoms referable to the kidneys, none of which showed shadows which might be diagnosed as kidney stones, seems to me to be of sufficient interest to present at this time."

Of these cases thirteen were in men and six in women, and all but three gave a definite history of severe trauma in the lumbar region, from three to twenty-five years previously. The exceptions were recent injuries. Five of the cases were operated upon, the injured process and its periosteum removed, with complete relief of symptoms referable to the kidneys.

C. H. DeWitt, M.D.

Head Sling Traction Technic in Cervical Spine Roentgenography. Philip Lewin. Am. Jour. Surg., February, 1930, VIII, 434.

The author shows a method of examining the cervical spine in certain cases, such as torticollis. The examination is made in such a manner that considerable extension is accomplished by traction on the head. This produces some separation of the cervical vertebræ, with an increased delineation of these bones.

Howard P. Doub, M.D.

Correction of Compressed Fractures of the Vertebræ. John Dunlop and Carl H. Parker. Jour. Am. Med. Assn., Jan. 11, 1930, XCIV, 89.

Compression fractures of the vertebræ are discussed. The frequency of compression fractures in accidents to workmen makes this injury of great importance to industrial surgeons. Roentgenograms are made to check the measurements of the contour of the bodies before and after reduction. In the authors' series the best reductions were accomplished when the injury was below the ninth dorsal vertebra.

The report and the discussion present a very interesting review of this subject.

C. G. Sutherland, M.B. (Tor.)

Dislocations of the Cervical Vertebræ: Report of Thirty Cases. Mitchell Langworthy. Jour. Am. Med. Assn., Jan. 11, 1930, XCIV, 86.

Dislocations of the cervical vertebræ are reviewed by Langworthy. Seventeen cases of bilateral and thirteen of unilateral dislocation are reported. These were treated with excellent results by the reduction manipulation of Walton.

C. G. Sutherland, M.B. (Tor.)

THE THYROID (THERAPY)

Concerning the Relationship between Fibroids of the Uterus and the Thyroid Gland. Frederick Howard Falls. Calif. and Western Med., November, 1929, XXXI, 305.

In a thousand women with fibroids of the uterus, there was no evidence that goiter was caused by the fibroids. Fibroids complicated by adnexal pathology and degenerative changes were not associated with a higher incidence of thyroid disease than other cases. The basal metabolic rate in a series of thirty-five cases, while higher than normal in the majority of cases, was not sufficiently so to be of special significance. In a series of one hundred thyrotoxic patients, there was no evidence of an abnormal incidence of fibroids as judged by the symptoms, vaginal findings, and history of operation for fibroids. Only 2 per cent of these cases had demonstrable fibroids. Fibroids and hyperthyroidism may occur in the same individual. The treatment of the thyroid should always precede that of

the fibroid unless the latter is an emergency, as twisted, infected, necrotic, or severely bleeding fibroid, and if emergency operation is necessary, adrenalin as a stimulant for shock should be avoided. Rest, Lugol's solution, and lobectomy may be necessary before attempting the necessary gynecological operation. Palliative management of the fibroid by radium, X-ray, ergot, and pituitrin, with blood transfusion in suitable cases, often give good results while the thyrotoxicosis is being brought under control. All patients with fibroids giving suggestive history or symptoms of thyroid disease should have a careful examination, including basal metabolic rate, to determine the presence and degree of thyrotoxicosis.

FRANCIS B. SHELDON, M.D.

TUMORS (DIAGNOSIS)

The Roentgen Diagnosis of Lipomas and its Practical Significance. Adib Chasin. Röntgenpraxis, March 15, 1930, II, 282.

Fat tissue absorbs roentgen rays to a lesser degree than any other soft tissue of the body, which makes it possible to demonstrate lipomas, especially in the extremities. Differentiation from other soft tissue tumors is fairly easy, and only a projection of the lipoma into the bone shadow may make it impossible to demonstrate it. A tumor shadow having about the same density as the surrounding muscle must be considered as of non-fatty nature.

H. W. HEFKE, M.D.

Differential Points in the Diagnosis of Lung Tumors. Robert Gantenberg. Röntgenpraxis, March 15, 1930, II, 241.

A series of interesting intrathoracic tumors is reported by the author, consisting of primary and secondary carcinomas of lung and pleura, and mediastinal tumors. One must not expect to make a definite diagnosis from a roentgen examination alone in many of these cases. Repeated examinations and observations of the clinical course of the disease were sometimes necessary to achieve it. In order to avoid mistakes one should always remember that tuberculosis in the form of the "early infiltration" may sometimes present itself as a round, well circumscribed shadow, especially in the subclavicular region. The clinical findings are of great importance in tumors of the mediastinum, particularly in Hodgkin's disease, which may show many different pictures. Fluoroscopy in the oblique and lateral positions should not be omitted; the situation of the tumor may be of great importance for the differential diagnosis.

H. W. HEFKE, M.D.

An Outline of the Diagnosis of Spinal Cord Tumors. Kenneth G. McKenzie. Can. Med. Assn. Jour., December, 1929, XXI, 696.

The author enumerates the various steps to be taken in the diagnosis of spinal cord tumors, *viz.*, examination for changes in sensation; examination for muscle weakness, atrophy of muscles and changes in the reflexes; examination for disturbances in the function of the bladder or rectum, and examination of the spinal fluid. The last named makes for earlier and more exact diagnosis. Details of the examination are the test for globulin, the cell count, and the Wassermann reaction test.

As a tumor of the cord tends to block the cerebrospinal fluid pathway about the cord, a number of tests, all associated with spinal puncture, have been devised to locate the site of blockade. The Queckenstedt test makes use of difference of pressure of the cerebrospinal fluid, as indicated by the manometer, when the jugular veins are manually compressed. If there is a block in the cerebrospinal fluid pathway, the pressure will not change; if there is no block, the pressure will rise as the jugulars are compressed. If, however, the block is only partial, this test is very difficult to interpret. The Ayer test is then employed. This consists in a double puncture, one above the site of the lesion and one below. If there is even a partial block, the difference between the rise and fall of the cerebrospinal fluid in the two manometers is very striking.

If, by means of the Queckenstedt or the Ayer test, it has been established that a block

exists, but the site of the block has not been determined with sufficient accuracy, then—and only then—is lipiodol injection employed. One cubic centimeter is injected into the cisterna magna, and fluoroscopic and radiographic examinations made in the upright position. If there is complete obstruction, operation should be performed within forty-eight hours, before the lipiodol becomes encysted by an inflammatory reaction. After the tumor has been removed, the head of the patient's bed is kept raised for a week, to make sure that the lipiodol finds its way to the bottom of the lumbar sac, where it becomes encysted and apparently gives rise to no trouble.

L. J. CARTER, M. D.

TUMORS (THERAPY)

Clinic on Malignant Diseases. Presented by the Staff of the Memorial Hospital, New York City, Sept. 19, 1929. Am. Jour. Surg., January, 1930, VIII, 122.

(This is the report of a clinic, showing the types of disease treated and the methods used.)

Giant-cell Tumors of Bone: With Special Reference to Treatment Technic. R. E. Hercndeen.—The author reports three cases of giant-cell tumors, all treated with X-ray therapy, and all showing a very satisfactory result. The third case demonstrated the development of tumors, similar to the primary one, at various parts of the body, but all these responded satisfactorily to radiation therapy.

Types and Treatment of Bone Sarcoma. William B. Coley.—This author discusses the osteogenic and endothelial myeloma of bone. The osteogenic type, associated with considerable new bone formation, has been found both extremely radioresistant and also rarely curable by amputation. Amputation followed by prophylactic treatment with mixed toxins of erysipelas and *Bacillus prodigiosus* has, in the writer's hands, given far better results. In forty cases of osteogenic sarcoma, including the endothelioma type, but excluding the giant-cell, the end-results showed 50 per cent of the patients to be alive in from five to twenty-five years. He does not believe that radiation therapy, alone or followed later by amputation, is as satisfactory as early amputation alone. In the endothelioma type of bone sarcoma, radiation therapy and toxin therapy should be employed, and an attempt made to save the limb.

In Coley's opinion, the present method of choice in the treatment of giant-cell sarcoma of the long bones is a very extensive curettage, swabbing out of the cavity with zinc chloride or pure carbolic acid, followed by a two or three month period of toxin treatment. He admits, however, that most of these cases can be treated satisfactorily by radiation therapy, but states that one out of four cases are found to be malignant.

The Malignant Granulomas. Lloyd F. Craver.—In this paper the author presents Hodgkin's disease, lymphosarcoma, and thymoma. He believes that occasionally the tumors which are apt to show the most radioresistance, present clinical evidence of considerable venous stasis, and the supraclavicular lymph nodes are apt to be very hard, stridor being present. On the other hand, those cases of thymoma which have shown penetration of the chest wall have been found to be rather radiosensitive. In the treatment of these deep-seated intrathoracic tumors, a moderately high voltage X-ray therapy—from 175 to 185 K.V.—is administered.

Neoplasms of the Vulva. William P. Healy.—In the three cases which he reports, the neoplasm developed on a pre-existing skin lesion. All of the cases had leukoderma, with thickening of the skin locally. Practically all tumors in this area are histologically of the adult, fully developed squamous variety of cancer, and, therefore, are relatively radioresistant. As the inguinal glands are practically always involved, both groins should also be irradiated. Following this treatment Healy favors vulvectomy, with dissection of one or both groins. He also follows this with heavy radiation therapy.

Malignant Growths of the External Genitalia. Benjamin S. Barringer.—In carcinoma of the bladder, the treatment at the Memorial

Hospital for the past fifteen years has been by means of radium implantation into the growth. No matter how accessible the growth for operative removal, this latter has never been attempted. In the majority of cases implantation is made under direct vision through the open bladder. The operative mortality of radium implantation in a cystotomy wound has been between 3 and 4 per cent. With this treatment they have been able to cure cases which were beyond operation, and the percentage of control in both papillary and infiltrated carcinoma is better than that shown by operative statistics. In prostatic carcinoma, deep X-ray therapy is given through five portals of entry, and, in addition, where the growth is small and confined to the prostate, gold radium seeds are implanted through the perineum into the carcinoma. The problem of residual urine is dealt with by a minor operation, namely, punching out the obstructive portion of the prostate through the urethra.

Rectal Cancer: Principles and Methods of Treatment at the Memorial Hospital. George E. Binkley.—A routine method of treatment is not employed, due to the varying factors which must be taken into consideration, namely, the condition of the patient, the stage of the disease, the location of the tumor, the degree of malignancy of the cells, and the degree of radiosensitivity of the cancer cells. Radiation therapy forms the basis of treatment, but colostomy and radical surgical excision are supplemented in all cases in which surgical interference offers an additional advantage. The types of radiation therapy now employed consist of external applications of radium and high voltage roentgen rays and interstitial applications of gold filtered emanation seeds.

Cancer of the Breast Treated Exclusively by Radiation Therapy. Burton J. Lee.—The treatment of cancer of the breast is often more difficult than that of cancer in other regions of the body, because of the widespread lymphatic system here encountered. Because of the disappointing results from the radical operation, the attempt has been made to control cancer of the breast in certain cases by irradiation alone. Several cases are presented, showing results and method of treatment. Two of the cases are recent, but show evidence of regression of the growth. The third patient, after eight and one-half years, shows no evidence of carcinoma remaining in the breast. The pathological report in 1920 was carcinoma simplex.

Fixed Pre-calculated Irradiation Dosage of Intra-oral Epidermoid Carcinoma. Douglas Quick and G. Failla.—The writers have made a detailed study of tissue doses received by tumor masses in successfully irradiated cases of intra-oral carcinoma. This has led them to believe that the lethal dose of the average intra-oral squamous carcinoma lies between seven and ten skin erythema doses, if delivered within a period of about ten to twenty days. From this experience in suitable cases, they have delivered to the tumor masses a pre-determined dose, and present three cases to show the results of this procedure.

Some Types of Radioresistant Tumors, with Results of Treatment. James Ewing.—The author presents several cases to emphasize the following points: (1) That the factors entering into radioresistance are varied; (2) that each tumor must be analyzed by itself in accordance with its known structure and clinical behavior; (3) that the results to be attained by radiotherapy in these tumors must be considered in the light of all the factors. Growth-restraint is generally all that should be attempted. He presents two cases of malignant bone tumors, the patients being alive about eight years after treatment by radiation therapy, followed several years later by amputation. One case of giant-cell tumor containing bone aneurysm was given radiation therapy and was later amputated, because of the aneurysm. In this case the radioresistance is apparent, not real. Two cases of neurogenic sarcoma were treated and were shown to be highly radioresistant. A case of liposarcoma of the capsule of the knee joint was also treated, but was found to be very radioresistant. In other cases, this type of sarcoma has responded to radiation. The last case was one of diffuse endothelioma of the upper end of the tibia. This was treated with radium packs, but three years later there was a recurrence of the growth and amputation was done. The sec-

tion revealed that the main tumor had been rendered highly fibrous and quiescent, but that the fibrous tissue contained many groups of well-stained viable tumor cells. The conditions represent abortive fibrosis.

HOWARD P. DOUB, M.D.

Pseudomucinous Cystadenoma: Analysis of Thirty Cases in which the Cysts were not Ruptured before Operation. James C. Masson and Robert Hamrick. Surg., Gynec. and Obst., April, 1930, L, 752.

Histological classification and a review of the frequency of these lesions, as reported by various authors, are given. An analysis of 30 unselected cases of surgical removal, unruptured before operation, is presented. The average age is 48.4 years, with range from 24 to 71 years, the greatest number (11) being in the sixth decade of life. Eight cases were malignant as determined by microscopic examination, with the average age of these cases being 55 years.

Symptoms given are: Gradual onset and progressive enlargement of abdomen, increase of intra-abdominal pressure, sensation of bearing down, urinary frequency, and dysuria. The average duration of symptoms was 20.2 months. In seven of the cases reported as malignant, the average duration of symptoms was 7.7 months. Cysts varied in size from 6 mm. to a mass larger than a normal pregnant uterus with an average from 15 to 30 cm. in diameter. The right and left sides were involved about equally in frequency when unilateral involvement was noted. Invasion was bilateral in 22.2 per cent of the benign cases, and 28 per cent of the malignant cases. No post-operative deaths.

One case (benign) had pre-operative roentgen-ray treatment before coming to the clinic. Five of the patients with malignant pseudomucinous cystadenomata had roentgen-ray and radium treatment post-operatively. A report of 18 of the 22 cases with a benign lesion is given, and of the eight which had malignant lesions. Of the latter group, two are dead; one 2 years 4 months after operation, and the other 3 years 7 months after operation. The last case had no post-operative radiation treatment and died apparently from recurrence. Five of the others have no reason to believe the pathological condition has recurred. The authors state that the treatment is surgical and "the use of roentgen ray and radium after operation is advisable in those cases in which evidence of a malignant condition is found by microscopic examination." There is no mention of the quality or quantity of the radiation which was used.

D. S. CHILDS, M.D.

URINARY TRACT

Roentgenography of the Kidneys and Urinary Tract by Means of Intravenous Injection of a New Contrast Medium—Uroselectan. M. Swick. Klin. Wchnschr., Nov. 5, 1929, VIII, 2087.

While investigating the excretion of selectan-neutral, which had been used therapeutically in the treatment of different coccus infections, it was discovered that excretion was more marked through the kidneys than through the bile. The first results by intravenous injection of animals were only sufficiently satisfactory to indicate the possibility of the method—whether or not the affinity for the kidney and the solubility of the substance could be improved. Oral administration in man was not successful. Continued investigation with the co-operation of the Chemical Institute finally evolved a substance which answered the requirements of safety, free solubility, and marked excretion by the kidneys. This has been named uroselectan. The iodine content of this drug is 42 per cent. It is well tolerated intravenously by mice and squirrels, and when injected intravenously in man, in proportionately much smaller amounts, yields very satisfactory pyelograms. The density of the roentgenogram depends directly on the condition of the kidney, as does also the time at which the best roentgenogram is obtained. The latter varies from one to two hours in the presence of good kidney function; to twenty-four or even thirty-two hours in poor function. When function is very

poor, no shadow is obtained. Whether normally or slowly excreted, the drug is not demonstrable in the blood after fifteen minutes. What becomes of the substance when not excreted has not been determined. In the clinical tests there were no deleterious effects of consequence. Death nineteen hours after injection in a girl of ten years of age was shown to be due to the severe and advanced nature of the pathologic conditions. The conclusion is that uroselectan is remarkably well tolerated in all surgical kidney diseases.

After intravenous administration, performance of which is very simple, films are taken at intervals, depending upon the rapidity of excretion. Fluoroscopy was also employed.

Reproductions of eight typical urograms are included.

EDWARD SCHONS, M.D.

Clinical Trial of Uroselectan. A. von Lichtenberg and M. Swick. Klin. Wchnschr., Nov. 5, 1929, VIII, 2089.

This new substance promises extensive clinical applicability of intravenous urography. The method offers satisfactory urography in cases of sufficient kidney function, and in all cases a roentgenologic function test, as well as a new chemical function test.

All cases examined with uroselectan were controlled by direct pyelography, and the results compared. Of 84 cases examined, the results were checked operatively in 35 cases, and by autopsy in one case. The results with uroselectan were technically successful and the films serviceable for diagnosis. No shadow indicated always either absence of the kidney or marked impairment of kidney function. The shadow was thus absent in advanced kidney tumor, pyonephrosis, severely infected obstructed kidney; also in marked cardiac insufficiency. In all cases of marked or total obstruction, if accompanied by infection, the shadow was absent. In cases of hydronephrosis, ureteral stone, and high grade renal disease due to stone, excellent pyelograms were obtained. A very interesting case of closed tuberculous pyonephrosis showed cavities in the upper half of the kidney.

The method was used in nearly all forms of primary and secondary surgical kidney pathology. In prostatic hypertrophy the dilatation of the pelves and ureters was well shown.

Professor von Lichtenberg is very enthusiastic about the possibility of studying the function of the ureters.

In 61 out of 84 cases examined, fully sufficient information for the preliminary handling of the case was obtained, cystoscopy, ureteral catheterization, and pyelography being necessary in the remainder. In 75 cases information as to function was sufficient to determine the operative indications. In all cases the examination of the patient was expedited and simplified, and in 70 per cent more radical examination could be avoided.

Indications for intravenous pyelography are given as follows: (1) cases where direct cystoscopy, ureteral catheterization, and pyelography cannot be done because of anatomical, pathologic, or technical reasons; (2) cases of obstruction where direct injection can be done only to the point of obstruction; (3) where the ordinary method is risky.

No contra-indications are at present mentioned, but it is stated that so far the ureters are often better shown by the old method.

EDWARD SCHONS, M.D.

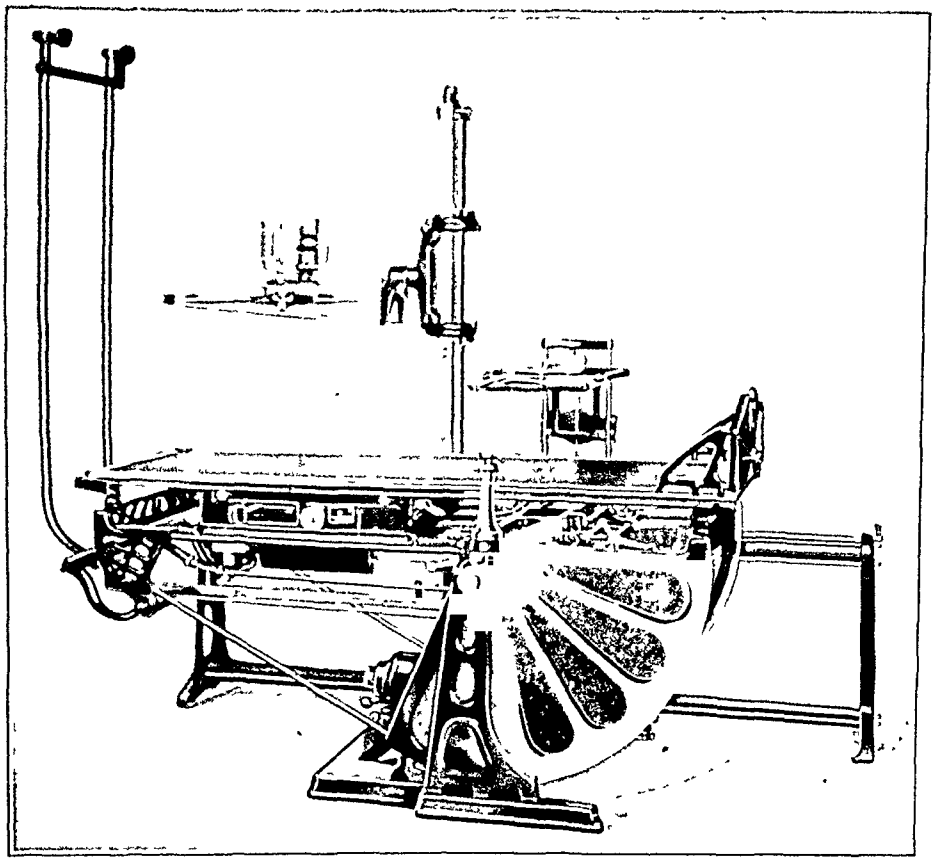
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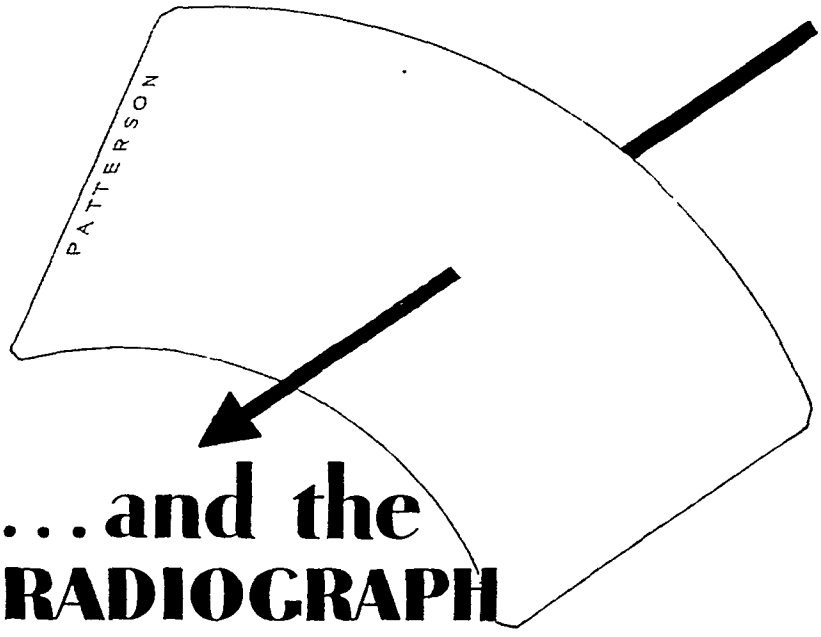
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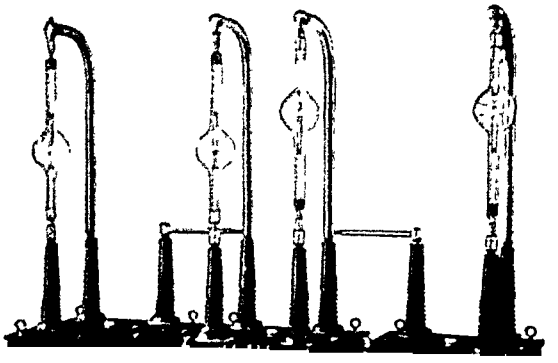
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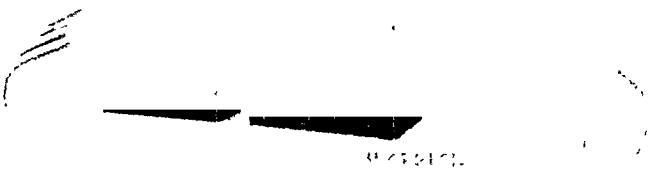
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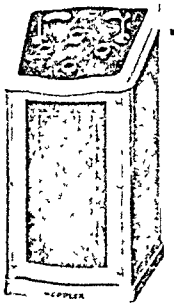
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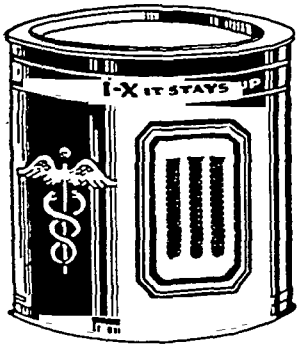
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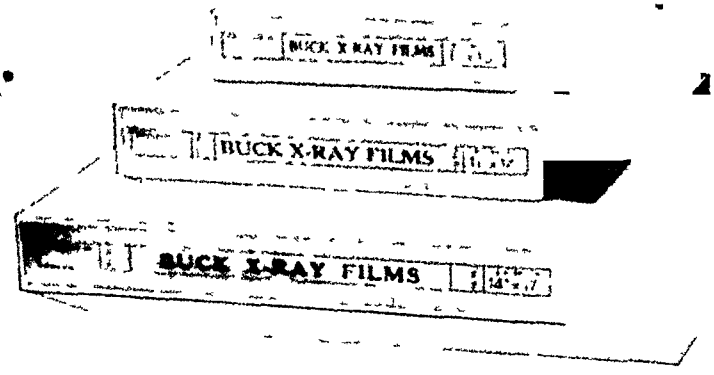
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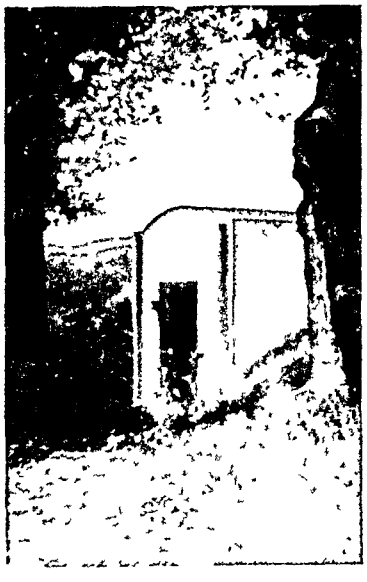
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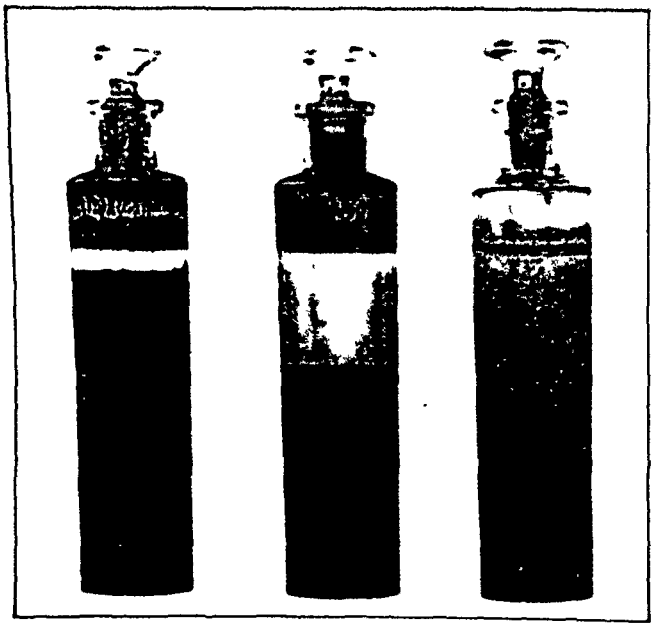
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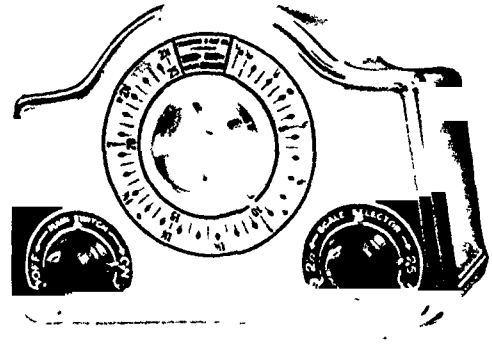
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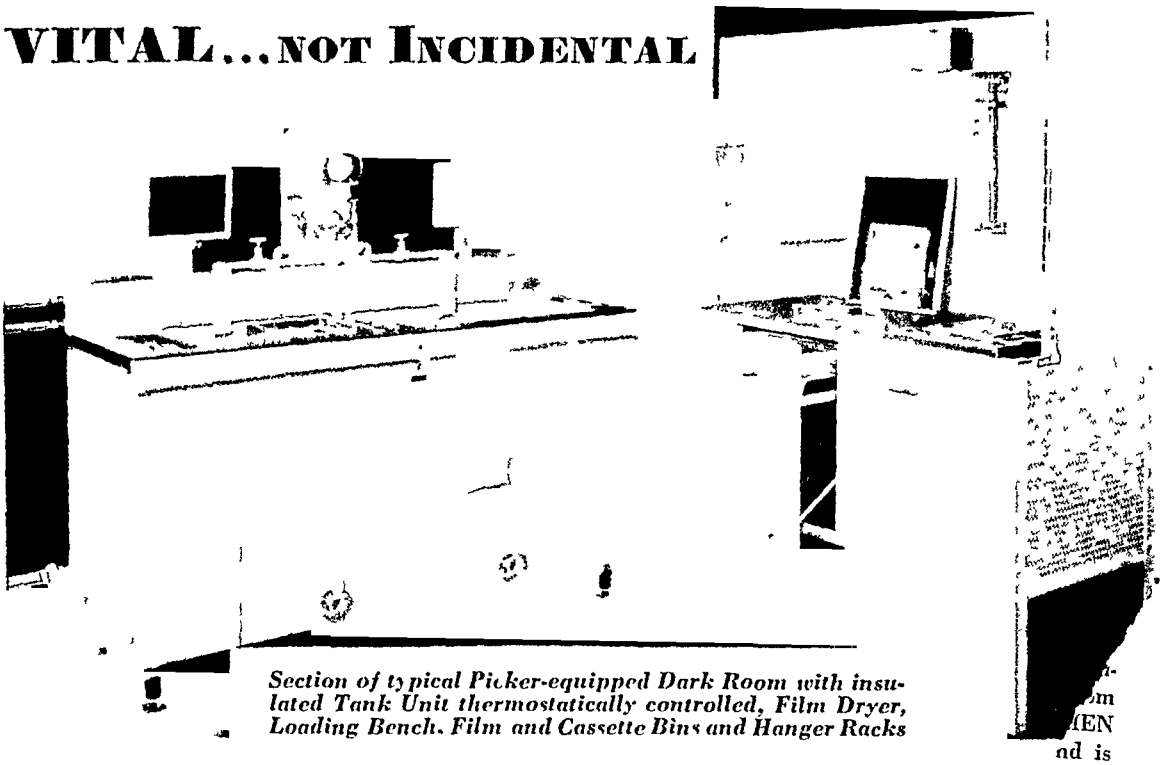
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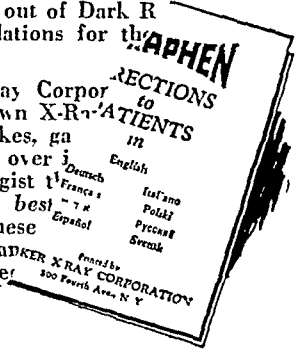
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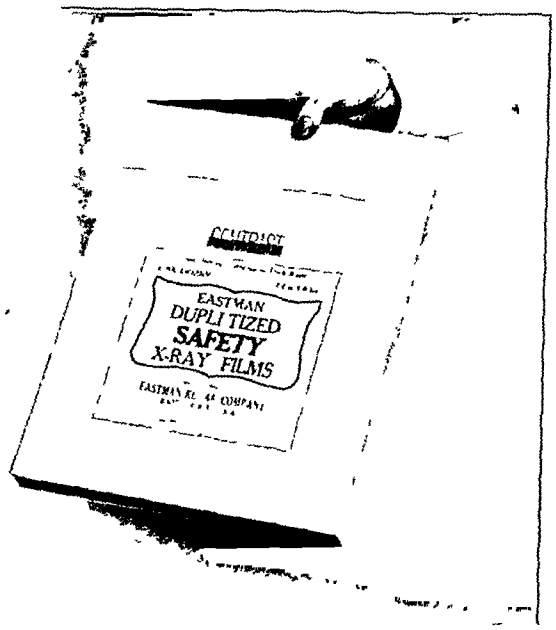
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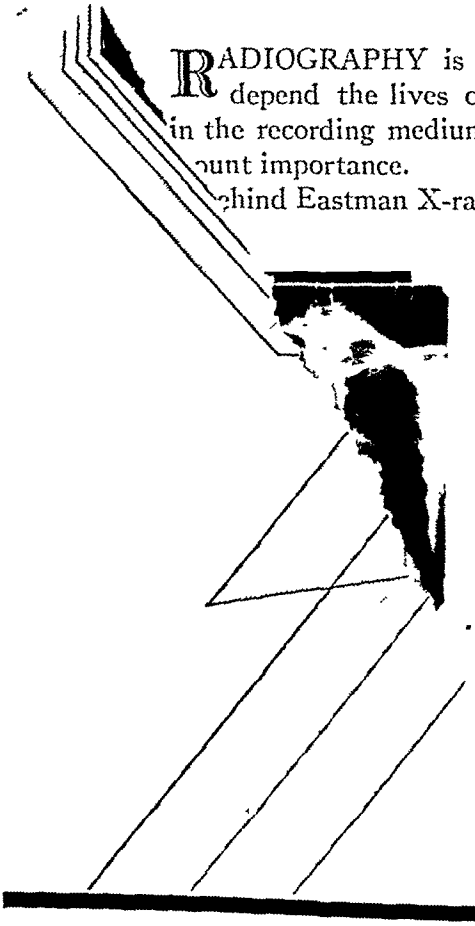
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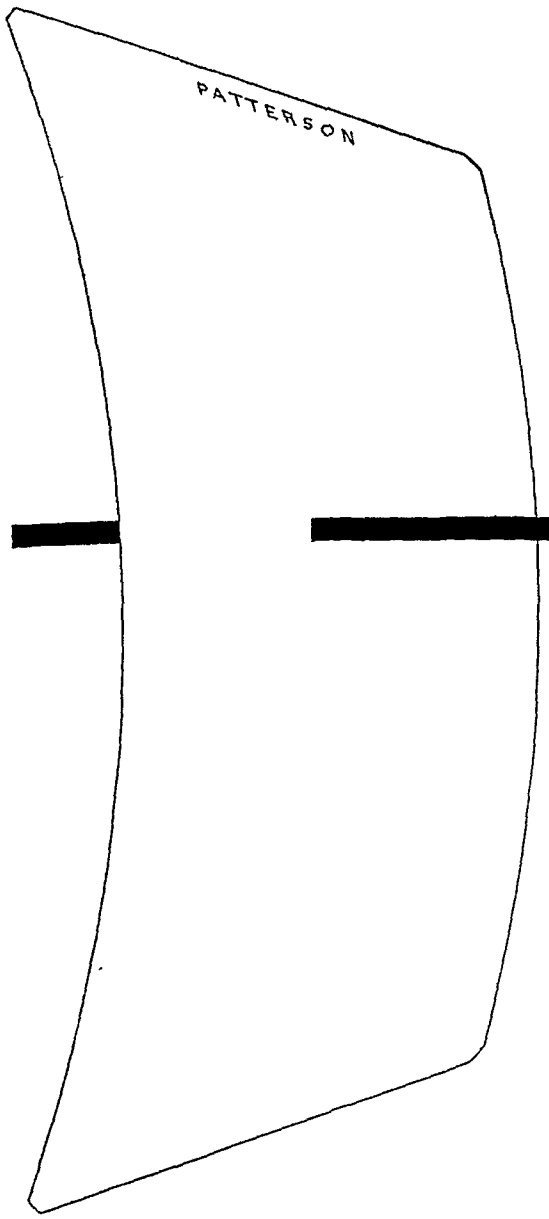
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M. J. HUBENY, M.D., 25 East Washington Street, Chicago, Ill. - - - - - - *Editor*

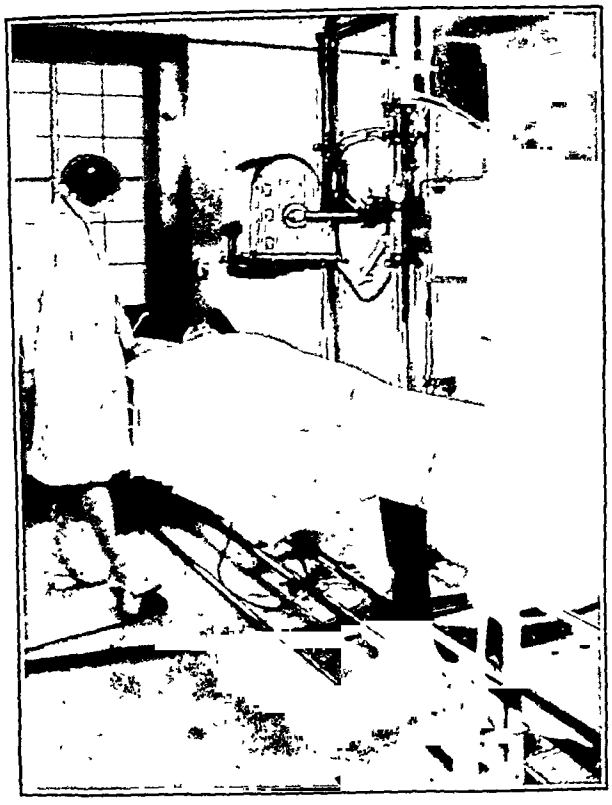
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PATHOLOGY OF RENAL TUMORS[1]

By ALLEN GRAHAM, M.D., Cleveland Clinic, CLEVELAND, OHIO

THIS paper is limited to a consideration of tumors of the kidney and perirenal region, particular attention being given to the gross pathological features which may have an important bearing upon the interpretation of roentgenograms. The more frequent types of intra- and extra-renal neoplasms and lesions simulating neoplasms are discussed briefly, and points of interest in each group are noted.

GENERAL CONSIDERATIONS

Embryological.—By reason of the embryological derivation of the kidney and the intimate anatomical relationship of the original anlage to the anlage of other important organs and structures in the immediate vicinity, it is not difficult to conceive of misplacements and inclusions of tissues which are not ordinarily destined to be integral parts of the fully differentiated kidney. The anatomical possibility of such inclusions affords one explanation for the occurrence of intra-renal neoplasms, the structure of which has little or no resemblance to the kidney substance.

An alternative explanation for the occurrence of heterotopic neoplasms in the kidney, which is also derived from embryological investigations, is based upon the fact that a mass of undifferentiated cells of common origin have the capacity of differentiating along diverse lines and of resulting in the establishment of organs and tissues so obviously different in structure and function that their primordial common ancestry is easily forgotten. Deviations from the line of normal differentiation or incomplete differentiation along the normal line may eventuate in the presence of two structurally different tissues of identical origin in the same organ. Granting this theoretical possibility, it should not seem strange that the apparently ectopic tissue may become neoplastic.

Each of the foregoing conceptions of the genesis of neoplasms has the sanction of authority. Neither is accepted to the exclusion of the other.

De-differentiation, Anaplasia, Metaplasia.—In the genesis of neoplasms increasing importance is attached to the possibility that adult tissue, under circumstances not too well understood, may revert to a more or less embryonal or undifferentiated state. The multiformity of renal neoplasms conceivably originating in such reverted tissue is limited primarily by the degree to which we are willing to admit that de-differentiation may proceed. If it be conceivable that a renal epithelial cell may revert to a cell

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having the potentialities of its ultimate ancestor, it would not be inconceivable that by a process of growth and re-differentiation it might develop the characteristics of an adrenal epithelial cell. Thus we have a third possible explanation of heterotopic neoplasms.

In a restricted sense, metaplasia implies the transition of one type of tissue into another type. That such a process has to be considered in the kidney is evidenced by the fact that the mucosa of the renal pelvis, which under normal conditions is not of the squamous type and has no keratohyaline material, may be totally converted into a type of epithelium morphologically identical with skin. From this altered mucosa epidermoid neoplasms may develop.

Statistical.—Renal neoplasms occur at all ages: more than 50 per cent of cases occur in the fourth and fifth decades. Experience has indicated the desirability of grouping the cases occurring in children separately from those occurring in adults. The predominating type of tumor differs in the two groups and there are also distinct differences in the clinical course, operability, dissemination, and response to roentgenotherapy. These differences will be given further attention under the discussion of the various types of tumor.

About 70 per cent of the cases of renal tumor occur in males. Comparative statistics concerning the incidence of the various types of renal neoplasms is increasingly difficult to obtain from the numerous clinics where comparatively large numbers of these cases are treated. This is due chiefly to differences in the interpretation of the two most frequently encountered types of neoplasms, namely, hypernephroma and carcinoma. It is not surprising, therefore, that in one clinic about 80 per cent of all malignant renal neoplasms may be classified as hypernephromata, and in another clinic less than 30 per cent are so classified. It is highly improbable that the Grawitzian tumor is less prevalent to-day than it was twenty-five years ago.

THE MORE FREQUENTLY ENCOUNTERED TYPES OF RENAL NEOPLASMS

Hypernephroma.—The type of lesion described by Grawitz is the most frequently encountered, and, therefore, is the most important neoplasm of the kidney. That it originates in adrenal cortical tissue, which is included in the kidney during its developmental period, has been disputed recently. Whatever may be the final judgment in the matter, segregation of this group of tumors seems amply justified by embryological, gross, microscopical, chemical, and clinical considerations. This type of tumor rarely occurs in children, but is the prevailing type of renal neoplasm of adult life, occurring in males more frequently than in females. It may be situated in any part of the kidney but is found more frequently in the upper pole. It is rarely bilateral.

The lesions observed at operation or autopsy are rarely less than three centimeters in diameter. Generally they are larger and may attain a diameter of from ten to fifteen centimeters.

Many of the smaller lesions are partially or completely encapsulated. In such instances the tumor increases by local growth without invasion of the surrounding renal tissue. The kidney parenchyma may become atrophic as the result of compression. Tumors of this sort may grow slowly and there are indications that they may be present for years without producing symptoms. We have no means of knowing what percentage of hypernephromata has such a benign beginning, nor what percentage pursues a relatively benign course. Whether or not these hypernephromata are encapsulated in their early stages, in the advanced stage they show an alarming tendency to

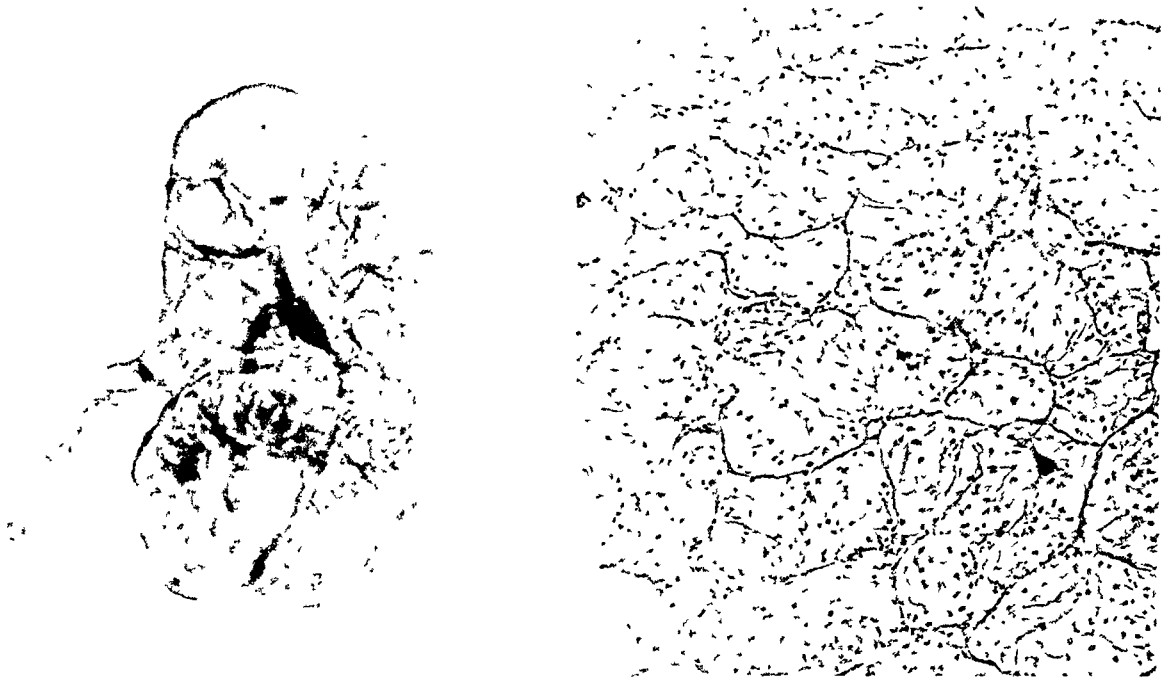


Fig. 1. Hypernephroma in lower pole of kidney. Histological structure typical

invade the capsule and the surrounding tissues and to behave in all respects as malignant neoplasms.

The larger tumors, in many instances, show little or no evidence of encapsulation and may infiltrate one or the other pole of the kidney (Fig. 1), the mid-portion (Fig. 2), or the entire kidney (Fig. 3). The dense, fibrous capsule of the kidney interposes a fairly efficient barrier against invasion of the perirenal tissues, although in a number of cases the renal capsule is perforated by the tumor growth. The renal pelvis likewise affords a modicum of restraint, but at times is perforated and the pelvic sac may be filled with tumor tissue.

One of the most striking features of hypernephromata is their tendency to invade the branches of the renal vein. From the renal vein the tumor tissue may extend continuously through the inferior vena cava to the right side of the heart. This may occur with or without adherence of the tumor tissue to the walls of the vascular channels. On the other hand, the tumor thrombus may remain limited to the branches of the renal vein or to the renal vein itself and a blood thrombus may extend to the inferior vena cava or the right heart. In either case, emboli may be set free and find lodgment in the lungs, the results being determined by the number, size, and location of the emboli. Tumor cells passing through the right side of the heart may also pass through the lung to the left heart, and thence to any part of the body.

On gross examination, hypernephromata may appear as circumscribed, encapsulated, or diffusely infiltrating masses. They are usually soft, light yellow in color, and are frequently complicated by varying degrees of diffuse hemorrhage and necrosis. On account of these qualities they can be recognized, in the majority of cases, from their gross appearance. In some cases the color is more white than yellow and the tumor is firmer in consistency than is usual, therefore, in such cases gross diagnosis becomes

more difficult. The amount of fibrous tissue in the tumor is also variable, particularly in the infiltrating tumors.

On microscopical examination, hypernephromata present extreme variations in old hemorrhages, with deposition of blood pigment, proliferation of fibroblasts, and inflammatory infiltration. The amount of doubly refractile lipoid material in the tumor cells also varies greatly in different

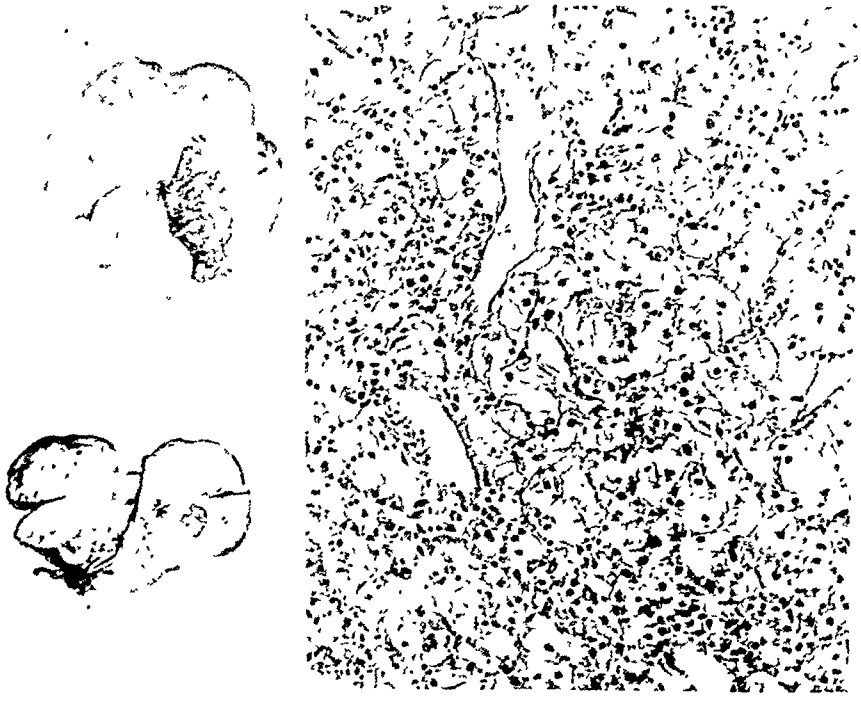


Fig. 2 Hypernephroma, dumb-bell shaped, in mid-portion of kidney. Histological structure typical.

structure. In almost all cases the usual alveolated arrangement of large, clear vesicular tumor cells with relatively small nuclei, the palisading of cells along a fine vascularized stroma or capillary network, the sharp outlines of the individual tumor cells, may be recognized in some portion of the tumor In the same tumor, however, there may be most extraordinary deviations from this typical histological picture. The tumor cells may be smaller, less vesicular, more spindle-shaped, and arranged in small, solid nests or long, solid cords, without definite palisading In other portions of the same tumor the tissue may have a pseudo-glandular (Fig 4) or pseudo-papillomatous arrangement. The picture may be complicated further by recent and tumors and in different portions of the same tumor.

The present tendency to classify the Grawitz tumor as a carcinoma originating from renal epithelium may be attributed very largely to its tendency to deviate from its histological type, as indicated above.

Carcinoma.—Second in order of frequency and importance among renal neoplasms are the carcinomata, which may be considered under two groups: (*a*) those arising from tubular or glandular epithelium, and (*b*) those arising from the pelvic mucosa.

(*a*) Probably the most important source of carcinomata in the substance of the kidney in adults is the adenoma, occurring with comparative frequency (Figs. 5 and 6),

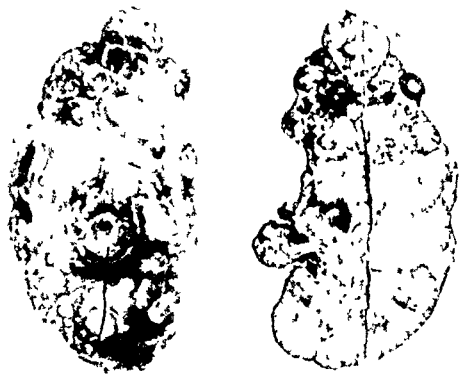




Fig. 3. Hypernephroma involving the entire kidney. Renal vein filled with tumor tissue. Histological structure, in part, pseudoglandular and papilliferous.

which is found in old sclerotic and fibrotic kidneys.

Adenomata are not infrequently encountered at autopsy as single or multiple lesions in one or both kidneys. They are generally small, white, circumscribed, non-encapsulated nodules not exceeding one centimeter in diameter. They are usually situated in the cortical portion of the organ and by their size and position give rise to no symptoms or deformity that can be recognized clinically. On microscopical examination they appear as adenomatoid or adenopapilliferous structures, apparently representing a transition of the renal parenchyma, and they generally are related to areas of atrophy and fibrosis. When the lesions are of considerable size a more or less well defined capsule may develop.

When the adenoma becomes malignant (carcinoma) fairly well circumscribed or diffusely infiltrating neoplasms of considerable size may result. Clinical manifestations (pain, hematuria, palpable tumor), anatomical alterations, and abnormalities noted in roentgenograms and pyelograms naturally depend upon the location, size, and rate of growth of the tumor, and whether or not the pelvis is secondarily involved.

Evidences of malignancy are deviations from the simple epithelium of an adenoma (atypical cytology, mitotic figures, invasion of stroma), and gross or microscopic infiltration of surrounding kidney tissue. Metastases from these tumors usually occur through the lymphatics. Dissemination

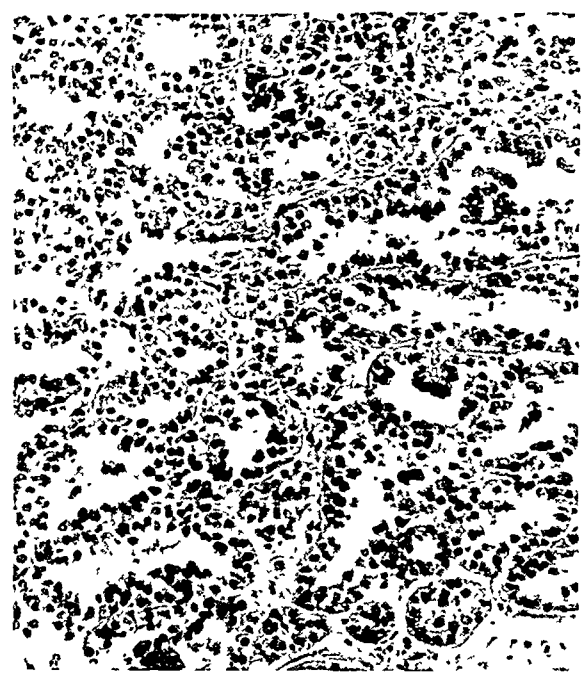


Fig. 4. Hypernephroma with pseudoglandular structure. Section from tumor shown in Figure 2.



Fig 5 Section of a white non-encapsulated nodule (adenoma) 2 mm in diameter, in cortex of kidney, such as is a probable source of many carnomata of the kidney in adults. (Figure 6 shows larger adenoma in the same kidney.)

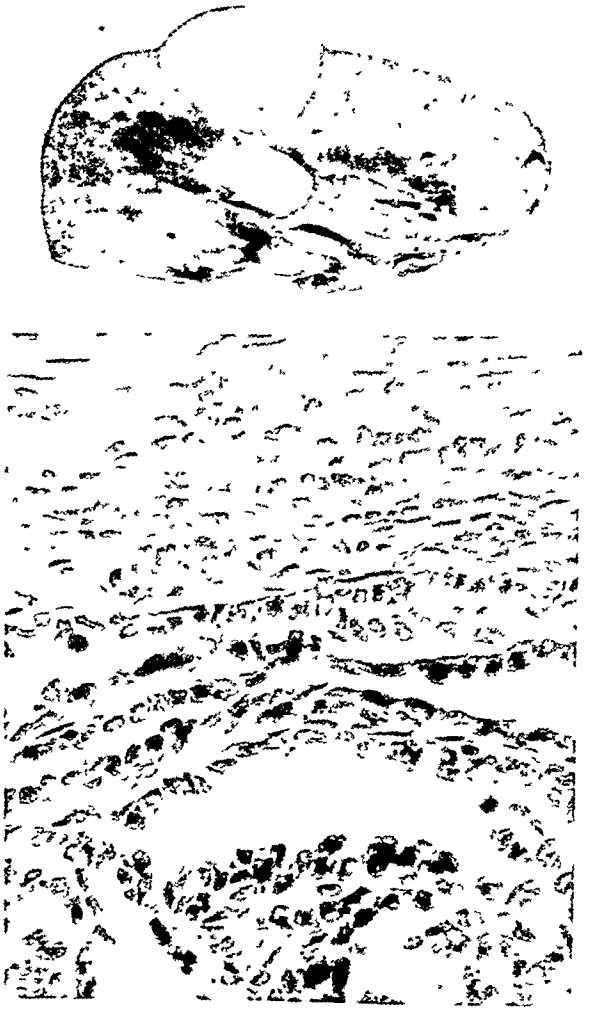


Fig. 6 Gross section of kidney through an encapsulated, yellow, cortical nodule, 1 cm in diameter. Macroscopically suggestive of adrenal cortical tissue or early hypernephroma; microscopically, a renal adenoma

rough the blood stream (to lungs, bones, etc.), which is such a striking feature of hypernephroma, is of rare occurrence in the type of carcinoma under discussion. In contrast to hypernephroma, however, which tends to remain localized in the kidney, carcinoma tends to invade surrounding structures. Hence the operative removal of a carcinoma may be more difficult and local recurrence more prone to follow than in the case of a hypernephroma.

In well advanced cases a carcinoma may grow into the pelvis, and at times it is difficult to determine whether the primary site of the tumor was in the kidney or in the pelvis. When the tumor is primary in the kidney, it is more likely to be of a glandular type

Carcinoma of the kidney in childhood is usually a different type and apparently has a different origin from carcinoma in adults. In children, the tumor is generally more undifferentiated or embryonal in type (Fig. 7), and in many cases it seems to be of a teratomatous nature, with one type of tissue predominant. Carcinomata in children may grow rapidly and form large tumors, but they show little tendency to distant metastasis. In some cases the tumor remains encapsulated and limited to the kidney; in others, it infiltrates diffusely and extensively. Some of these tumors are remarkably radiosensitive, quite in contrast to carcinomata in the adult.

(*b*) Carcinomata arising in the renal



Fig. 7. Section of an embryonal glandular carcinoma from a child's kidney. No mixed or teratomatous structures have been detected. This tumor was remarkably sensitive to roentgen therapy.



Fig. 8. Papilloma of the renal pelvis. The growth is principally intrapelvic. There is very little invasion of subjacent tissue.

pelvis are of two types—papillomatous and epidermoid.

Papillomatous growths of the renal pelvis (Figs. 8 and 9) are somewhat similar to papillomata of the bladder, and, like the latter, tend to become malignant. The tumor may be limited to one or two calices or it may fill the entire pelvis. In some cases the growth shows little tendency to invade the kidney substance; in other cases the kidney may be extensively infiltrated or largely destroyed. Secondary implantation along the course of the ureter or even into the bladder may occur. Hematuria is almost a constant clinical finding. The ureter may become blocked by tumor tissue or by a blood clot, and hydronephrosis may result. Calculus may form in the pelvis, especially if secondary infection has occurred. As long as these tumors are confined to the pelvis, metastases are slow to develop, but when the kidney is involved metastases may take place through the lymphatics. Blood stream metastasis is not a frequent mode of dissemination.

Tumors arising in the pelvic mucosa but growing into the kidney substance rather than into the lumen of the pelvis, have the structure of an inverted papilloma. Such tumors are referred to by some authors as epidermoid carcinomata. They are exactly comparable to similar lesions in the bladder. Generally they produce a non-keratohyaline material and do not form pearls.

A true epidermoid carcinoma with keratohyaline material and pearl formation may arise in the pelvis of the kidney, the seat of leukoplakia. These are ulcerative lesions, comparable to similar lesions occurring in the skin. They infiltrate the kidney substance and their usual mode of metastasis is through the lymphatics. These tumors are of relatively infrequent occurrence; they are usually found in chronically infected kidneys or in association with calculus.

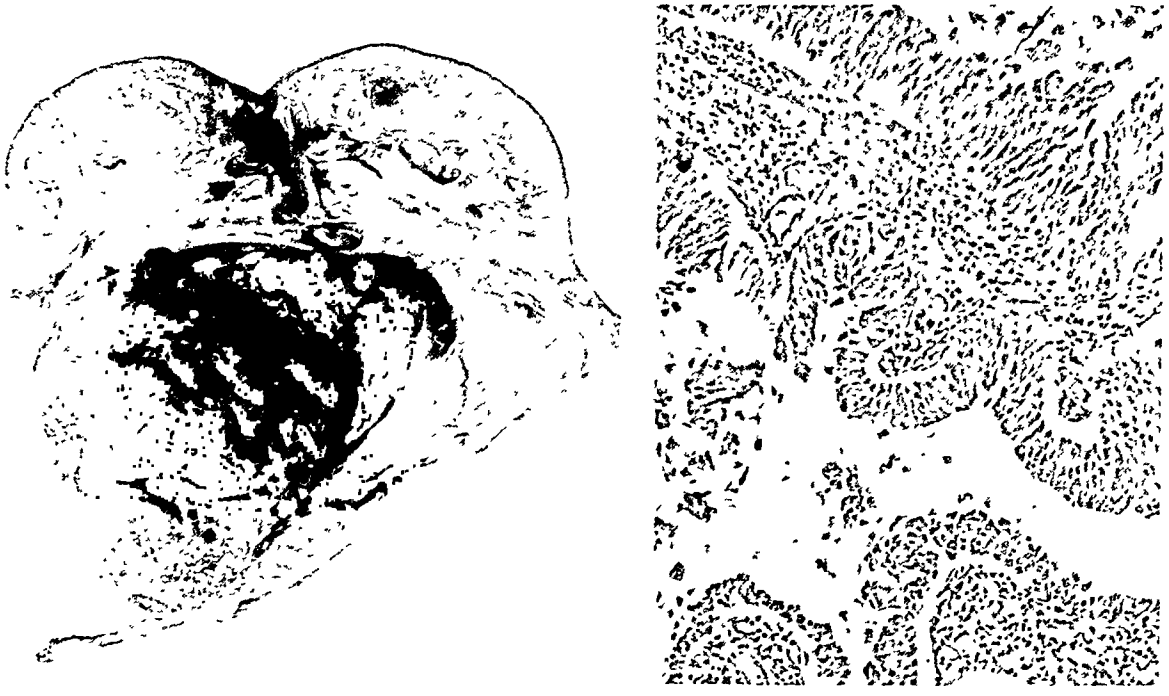


Fig. 9. Intrapelvic papillary carcinoma, the usual type of pelvic neoplasm. A growth of this type may be fungating and only slightly invasive or ulcerative and extensively invasive. Under the latter circumstances it is frequently referred to as "epidermoid carcinoma."

Sarcoma.—True sarcoma in the sense of a malignant tumor arising from the supporting tissue (capsule, stroma, or adventitia of blood or lymph vessels) is rarely observed in the kidney as a primary tumor. A rather hurried search of the records of the Cleveland Clinic for the past eight years has failed to disclose a single case. It is more than probable that a large percentage of cases appearing in the literature under the heading of sarcoma would be more appropriately classified as cases of embryonal carcinoma or of mixed tumor of one type or another.

Mixed Tumors.—Mixed tumors constitute the third group of renal neoplasms in order of frequency and importance. They are not a homogeneous group and do not conform to a type. In this group are included tumors which are probably variable in derivation, and certainly variable in composition. The one feature that characterizes them as a group is the fact that they comprise the majority of renal neoplasms which occur in childhood. Some of these tumors are probably of a teratomatous nature, although it is extremely difficult to decide their nature on account of inability to recognize derivatives of three germ layers. Components from two germ layers are not infrequently encountered. The tissues which enter into the composition of these tumors are embryonal or undifferentiated. The failure of differentiation is such that, in many instances, it is impossible to distinguish with certainty between epithelial and mesoblastic cells.

Mixed tumors usually grow rapidly, form large, clinically detectable masses, are difficult to differentiate from pararenal, retroperitoneal, and intraperitoneal tumors, and show surprisingly little tendency to disseminate distant metastases. They are frequently unaccompanied by symptoms other than a swelling, anemia, and loss of strength. On gross examination many of

them are found to be well encapsulated, and when thus limited they may displace, rotate, or deform the kidney without seriously impairing its function. In this stage, they are usually relatively free from adhesions to surrounding structures; nevertheless, complete surgical removal is rarely accomplished on account of the size of the tumor, the thinness of its capsule, the friability of the tissue, and its great vascularity. Even though they may be encapsulated at first, many of these tumors perforate the capsule and infiltrate extensively into the surrounding tissues.

On microscopical examination, the structure of these tumors is found to be extremely variable. The tissues are rarely of a single uniform type. Generally there are more or less intimate admixtures of epithelial and mesoblastic elements, which in themselves show remarkable morphological variations. The epithelial portions may have a glandular, papilliferous, alveolar, or solid arrangement, or any combination of these. The mesoblastic portions may consist of embryonal connective tissue, mucoid tissue, embryonic muscle tissue, or various combinations of these. Cartilage and bone are not so frequently encountered. Either the epithelial or the mesoblastic elements may dominate the picture. Necrosis, hemorrhage, and cyst formation are frequent complications. When metastases occur the dissemination may be by the blood stream or the lymphatics, or by both routes.

Many of the tumors are radiosensitive and may be kept under control for a considerable period of time by roentgen therapy. The response to irradiation depends, as in the case of tumors generally, upon the degree of undifferentiation. Metastases and recurrences also are radiosensitive in some instances.

Extra-renal Tumors.—Lipomata may develop in the peripelvic fat of normal kidneys



Fig. 10. Photomicrograph of a true epidermoid, pearl-forming carcinoma of the renal pelvis, probably originating in leukoplakia. Such tumors are usually ulcerative and invasive.

and result in displacement of the organ and deformity of the pelvis. They may develop in the fat which is deposited in kidneys that are atrophic as a result of interference with the circulation or as a result of chronic infection, with or without calculus, or they may develop in the perirenal fatty capsule and by their size misplace an otherwise normal kidney.

Fibromata, fibrolipomata, or *fibromyxomata* may develop in the perirenal tissue. The myxomata may either be encapsulated or diffuse and may become sarcomatous. These tumors may displace, but usually do not invade, the kidney.

Retroperitoneal neoplasms such as lymphoblastoma, common sarcoma, endothelioma, and tumors of the adrenal may simulate renal neoplasms.

Subhepatic, intrahepatic, subdiaphragmatic, or *psoas abscesses* and *omental* and

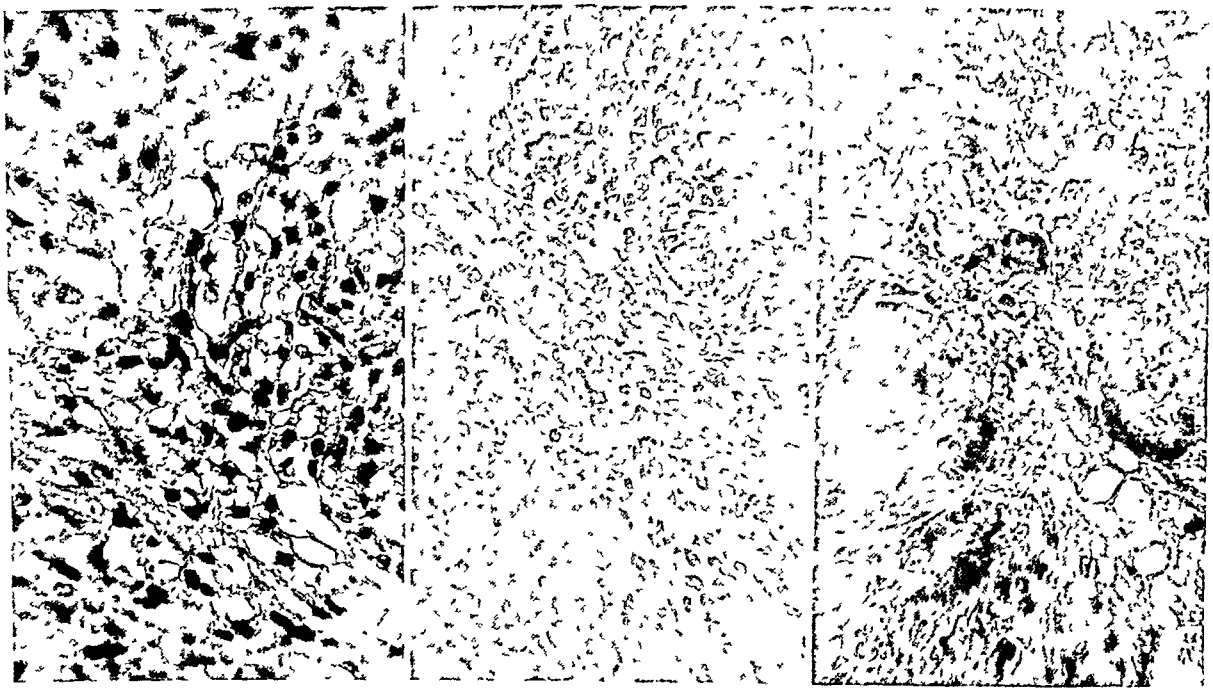


Fig 11 Photomicrographs of a renal neoplasm in childhood, of mixed type *Left* loose reticulated tissue, suggestive of sarcoma *Middle* compact cellular tissue, suggestive of carcinoma *Right* embryonal glandular tissue in loose cellular stroma

mesenteric cysts may simulate cystic tumors of the kidney.

ROENTGENOLOGICAL INTERPRETATION IN RELATION TO THE PATHOLOGY OF RENAL TUMORS

Roentgenograms of the kidney are photographic representations of the state of the organ at the time of exposure. They indicate the relative size, position, and contour of the kidney, and show relative variations in the density of the shadow of one portion of the kidney as contrasted with another, or of the kidney as contrasted with its surroundings Additional evidence of normality or abnormality is made available by the efficient injection of opaque media, as in pyelography, which permits visualization of the calices, pelvis, and ureter.

The co-operation that has been established between the urologist and the roentgenologist accounts in great measure for the high degree of accuracy achieved in the interpretation of variations from the roentgenogram and pyelogram of the normal kidney The possibility of the recognition of neoplasms, extra-renal, intra-renal, or intrapelvic, as opposed to anatomical defects, congenital malformations, and infective processes, including tuberculosis and calculus with its sequelæ and complications, is very gratifying

There are, however, certain limitations in the differentiation of the types of tumors that may be responsible for abnormal appearances in the roentgenogram or pyelogram This is due to the fact that dissimilar types of neoplasms may present similar gross physical characteristics, and also to the fact that the same type of neoplasm may present dissimilar gross physical characteristics on different occasions and in different cases In general, it is simpler to differentiate between a benign and a malig-

nant tumor, which, after all, is the more important part of the problem, than it is to differentiate one type of benign neoplasm from another or one type of malignant neoplasm from another. Roentgenograms and pyelograms, alone, fall short of what is possible in the way of diagnosis when proper consideration is given to additional data such as age, clinical findings, and numerical probability.

CLINICAL ASPECTS OF GENITO-URINARY TUMORS[1]

By W. E. LOWER, M.D., Cleveland Clinic, CLEVELAND, OHIO

ALLURING as would be a complete discussion of the many clinical aspects of tumors of the urinary tract—symptoms, indications for treatment, methods of diagnosis, etc.—the time at my disposal will permit of a discussion of only some of the diagnostic methods and the treatment employed in cases of tumors of the urinary tract, together with a report of such end-results as are now available. I wish, however, to express the deep sense of obligation which is felt by every urologist to the radiologists who are making possible a progressively increasing percentage of correct pre-operative diagnoses of tumors of the urinary tract, and who are constantly studying methods for the application of radiation in their treatment, with a progressively increasing percentage of cures.

The diagnosis of bladder tumors is not as a rule difficult with the aid of the cystoscope, but the type of tumor is occasionally difficult to interpret from inspection. The majority of tumors in the bladder are papillomata and carcinomata of various types. Occasionally it is difficult to differentiate tumors of the so-called inflammatory type from those which are the truly malignant. A series of such cases has been reported by Dr. J. J. Joelson and myself (*Surgery, Gynecology and Obstetrics*, October, 1927, XLV, 417-422). The majority of inflammatory tumors of the bladder are tuberculomata. Occasionally the bladder is so irritable or so contracted that inspection with the cystoscope is not possible. In such a case cystograms will generally help to establish the diagnosis. This phase of the subject will be discussed by Dr. B. H. Nichols.[2]

Practically all tumors of the bladder are potentially malignant because they all have a tendency to recur. The cardinal symptom is hemorrhage; and whenever there is blood in the urine, the possibility of a bladder tumor must be considered.

In contrast to the diagnosis of tumors of the bladder, the cystoscope is of limited aid in the diagnosis of tumors of the upper urinary tract. Here we must depend to a large degree upon the X-ray to help us out. The tumor most frequently found in the pelvis of the kidney is the malignant papilloma. A tumor of this type as a rule produces but little enlargement of the kidney unless hydronephrosis is present, so that palpation is of no aid in making the diagnosis, which can be determined only by a proper interpretation of the pyelograms.

In the case of the solid tumors of the kidney, tumors involving the cortex, diagnosis is more easily made, since the enlarged kidney is generally palpable. Often a tumor of this type can be diagnosed without the aid of either the cystoscope or the X-ray. It is well known that any large solid tumor palpable in a child's abdomen is probably a malignant tumor of the kidney. It is my impression that in cases of kidney tumor in children, hemorrhage is less frequently encountered than in cases of tumor of the kidney in adults.

In determining the source of bleeding in a case of hematuria, the possibility must be borne in mind that there may be a tumor situated in the lower end of the ureter. In a case of this type the cystoscopic observation will often show the bleeding to be coming from the ureter, but when the catheter is passed up the ureter for a considerable distance, the urine will come clear.

When papillomata of the bladder are not too large and are not situated too near the internal sphincter of the bladder, the proper

[1]Read before the Radiological Society of North America at the Fifteenth Annual Meeting, at Toronto, Dec. 2 to 6, 1929.

[2]See page 547.

treatment is by fulguration. If the tumors are very large, or are multiple, as sometimes happens, so that the entire bladder is filled with tumor masses, it is better to open the bladder and cauterize the tumors from above. I have found the most satisfactory method of cauterization to be by the use of a soldering iron. In some cases, after searing over almost the entire bladder with this soldering iron, I have been amazed to find that the tumors have entirely disappeared, and that within a very short period the bladder mucosa has become healed.

Bladder tumors of the histologically malignant type present a somewhat different problem, for these tumors metastasize to the adjacent lymph glands, or may produce a metastasis at some distant point. I have had one case in which a metastasis from a bladder tumor appeared in the brain. This was reported by Dr. R. M. Watkins and myself in the *American Journal of the Medical Sciences* (March, 1924, CLXVII, 434).

When the tumor, even though malignant, is not of the infiltrating type, wide resection of the bladder is still, in all probability, the best procedure, but for the infiltrating type of tumor I think there is no doubt that radiation has displaced operation as the preferred method of treatment. For this, the following reasons exist: (1) the immediate mortality rate is lower; (2) the prolongation of life is probably greater; (3) the economic result is probably better. This conviction is the outcome of a study of the end-results in our own series of cases of tumors of the bladder consisting of 523 cases, 182 of which were benign and 341 malignant tumors. Between 20 and 23 per cent of the histologically malignant cases treated surgically are known to have survived over the five-year period, and in some cases there has been no recurrence for as long as twenty years. It is still too soon to know what the results of treatment by radiation alone are going to be. Dr. Portmann will analyze the data at hand later in this symposium.[3]

Papillomatous tumors are easily transplanted and great care must be taken in their removal by the open method, or the cells may be transplanted into a cut surface and a tumor will develop in the scar. A frequent re-check of all cases of papillomatous tumors of the bladder is essential, as they so often recur. The reason for the recurrence probably is that the removal of the tumor does not remove the cause which produces it, and the conditions which produce the first tumor may be present to start the growth of other tumors.

Primary tumors of the ureter are quite rare. We have had one case. Secondary involvement of the ureter, especially of its lower end, is of more frequent occurrence. This is usually papillomatous in character and is due to a transplant from a papilloma of the kidney pelvis. The question as to whether or not the entire ureter should be removed in cases of tumor of the kidney pelvis must be considered. A section across the ureter at the upper end may show that the ureter is perfectly smooth and uninvolved, but later a hemorrhage may occur, due to a transplant at the lower end of the ureter, the cells having been washed down with the urine and accumulated like driftwood just behind the uretero-vesical junction. If there is some contra-indication to the removal of the ureter at the time of the kidney operation, it should be borne in mind that the ureter is still *in situ* and may perhaps be removed at a second operation.

Tumors of the kidney, other than cysts and hydronephroses, are nearly always malignant. There are a few benign tumors which grossly simulate malignancy, namely, the lipomata, leiomyomata, and myxomata. Our cases of malignant tumors of the kidney are 115 in number: 19 per cent of these

[3] See page 542.

patients have survived operation for over five years, one patient has survived for fifteen years, and one for twenty-five years. We are still undecided as to whether or not these tumors should be removed primarily and then treated with X-ray, or be given a course of X-ray first and then removed. I think this depends somewhat upon the size of the tumor and the amount of fixation. I have seen one case in which the tumor, which was extremely large and fixed, became definitely smaller and movable by the use of radiation.

Malignant tumors of the urinary tract still present the most difficult problem in genito-urinary surgery. I have a growing conviction that in the future radiation, or a combination of radiation and surgery, will be employed more often than has been the case in the past. Here, as in the case of tumors elsewhere, early recognition and early treatment will give the best results.

TUMORS OF THE URINARY TRACT[1]

By B. H. NICHOLS, M.D., Cleveland Clinic, Cleveland, Ohio

WHEN a patient presents himself for examination because of frequency and blood in the urine, cystoscopic examination may reveal a large or small tumor in the bladder. There are cases, however, in which the cystoscope can not be introduced into the bladder, and also some cases in which a clear field can not be maintained in the bladder on account of persistent hemorrhage.

In the latter case, cystography offers a very easy method of determining the presence of filling defects, provided the tumor present is so large as not to be overshadowed by the remaining portion of the bladder. Tumors of the bladder are best observed by fluoroscopic cystography, as a small amount of solution in the bladder may outline the filling defect, while if the bladder is distended with fluid, the filling defect can not be seen. Films should be made obliquely in both positions as well as antero-posteriorly.

Kohnstam and Cave also outline a unique method of observing tumors of the floor of the bladder. The bladder is filled with a non-opaque solution, a small amount of which is then withdrawn, and lipiodol or iodized oil is floated on the remaining fluid. Then by placing the patient in the Trendelenburg position, the floor of the bladder can be well outlined and the presence of a filling defect can be determined. This method is particularly applicable also in the study of tumors of the prostate gland.

Extensive blood clots in the bladder are sometimes mistaken for filling defects due to the presence of a tumor. Enlargement of the prostate also will make a filling defect in the floor of the bladder. This should not be mistaken for a tumor, however, if it is remembered that the prostate is usually regular and smooth in outline, while tumors are irregular and asymmetrical in outline.

Tumors of the ureter are generally of the papillomatous type and are usually transplants from a primary tumor of the kidney. They are very difficult to diagnose by the use of the ureterogram alone as stricture and other deformities produced by infection may closely simulate a tumor. A diagnosis of a primary ureteral tumor can be made only by the use of cystoscopy, by close observation of the clinical symptoms, and by the finding of an irregular filling defect in the ureteral lumen.

Tumors of the kidney are usually suspected when a palpable mass is found in the region of the kidney, or when pain, accompanied by marked hematuria, is present. These symptoms, however, may not necessarily be present. It is a fairly accurate estimate that only about 50 per cent of tumors of the kidney are accompanied by hemorrhage. Tumors unaccompanied by hemorrhage are usually of the hypernephroid type. In the diagnosis of tumors of the kidney in the absence of clinical signs or symptoms, a roentgenological examination is indispensable. In the case of a palpable mass in the kidney region, suspicion that the mass is due to the presence of a tumor may often be confirmed by a stereoscopic examination of the kidney region, as tumors of this type are usually confined to the pole of the kidney and show an enlargement of the kidney outline at the site of the tumor.

Pyelography has been found to be the best method of procedure for the diagnosis of tumors of the kidney, a method which fails only when the tumor is confined to the capsule or cortex or when there is present in the kidney pelvis a very small tumor of the papillary type, the shadow of which may be completely lost in that of the pyelo-

[1]Read before the Radiological Society of North America at the Fifteenth Annual Meeting, at Toronto, Dec. 2 to 6, 1929.

graphic medium. In the latter case a pyelogram made after the injection of air will disclose a small tumor of the pelvis, but we have hesitated to inject air into the kidney pelvis if hemorrhage has occurred, on account of the possibility of an air embolism. However, there is probably little danger in the procedure. All other types of tumors may usually be detected by the irregularity of outline, elongation or obliteration of the calices or pelvis. Tumors at the lower pole of the kidney may displace the ureter or obstruct it, with resultant dilatation. Benign tumors of the kidney usually show a smooth, regularly outlined deformity of one or more calices, with displacement or compression. Such deformities may also extend to the kidney pelvis, depending upon the size and location of the growth.

This would seem to be a simple method for the diagnosis of benign growths of the kidney. However, there is a large group of malignant tumors of the hypernephroid type, many of which are definitely encapsulated, and produce a clean-cut deformity of the pelvis or calices, and for this reason are not always recognized as malignant tumors.

Most malignant tumors of the kidney, except those of the hypernephroid type, produce an irregular filling defect indicating invasion of the kidney structure, and in any case, therefore, such findings lead to the suspicion that the tumor is malignant. It must be understood that pyelographic findings are limited to the recognition of the presence of a tumor. In only a fair percentage of cases can the pyelogram provide sufficient evidence for the differentiation between a malignant and a benign tumor. Metastases of the hypernephroid group to bones or the chest are characteristic round nodules, and will establish the type of kidney tumor if they are present.

The differential diagnosis of tumors of the kidney consists in the recognition of anomalous pelves, of a polycystic kidney, and of the presence of infection or of an ureteral obstruction, with resultant hydronephrosis.

Hydronephrosis in the presence of a tumor may be due either to the actual obstruction of a calyx or of the ureter by the tumor, or to a simple compression of the ureter, in which case the dilatation will be proximal to the point of obstruction. When a tumor is accompanied by hemorrhage, the presence of blood clots may produce obstruction of the ureter, with resultant hydronephrosis, which is usually accompanied by deformity of a portion of the pelvis or calyx, and may be differentiated from a general dilatation from other causes by the asymmetry of the pyelographic shadow. A hydrocalyx may be the exception, but if the entire pelvis is outlined, or if a calculus is found in a calyx, the presence of a tumor can be ruled out. Infection will seldom simulate a neoplasm. Pyelitis produces a characteristic clubbing of the calyx, and pyonephrosis produces destruction and fragmentation of the pelvis, the entire kidney usually being involved. Infection may accompany a tumor and make the diagnosis difficult. If a deformity of the pelvis is due to blood clots, this may be determined by repeated examinations, or by making a pyelogram after the pelvis has been washed out.

Congenital polycystic kidneys perhaps offer the most difficult problem in differential diagnosis, as elongation of the calices and deformity of the kidney outline by the cystic areas may present a picture closely simulating that presented by a kidney tumor. However, in the case of a cystic kidney a pyelogram of the opposite side will usually reveal the condition to be bilateral, while in the case of a tumor the condition is confined to only one kidney.

In making my contribution to this symposium, it has been my intention not to enter into a discussion of the pathology or the

symptomatology of tumors of the urinary tract. I will leave this to my colleagues.

DISCUSSION

DR. G. E. PFAHLER (Philadelphia): First of all, I am somewhat surprised, after all these excellent procedures have been described, that no mention has been made of the examination of tumors of the bladder by pneumocystography. One can very clearly outline practically any tumor of the bladder by this very simple procedure, the means of which are in every physician's, every radiologist's, hands. The procedure has been used by me since 1911, and I described it in 1916. It consists simply of the introduction of a soft rubber catheter, an atomizer bulb to distend the bladder with air, and then clamping the catheter with forceps and making the film, first with the patient lying supine and then in the prone position. The prone position always gives the better film, but sometimes in rolling the patient over you may lose your air. Sometimes this occurs because the catheter is expelled, but that is not necessary, because if you exercise care the catheter will not come out The catheter can be held in place by the fingers while the patient rolls over.

These tumors may be very large, and they may show involvement of the bladder wall; if the bladder wall is infiltrated, it cannot expand. Now this is not only of definite advantage in outlining and determining the location and size of the tumor but it serves as a very excellent guide to the radiologist in determining to what extent the tumor is decreasing under radiation, and whether it is cured completely. I agree with Dr. Portmann that the radiation treatment is very useful in the treatment of these bladder tumors.

A MEMBER: I think this Symposium has been exceptionally well arranged, because we have the combination of a pathological, a diagnostic, and a therapeutic paper on the subject of tumors of the urinary tract. We must remember that they are all dealing with pathology, and we must all understand pathology before we can attempt the reading of the graphic portrayal of the diagrams. This is the way we should always arrange subjects of an unusual character.

The relation of the blood channels in hypernephroma to the actively growing tumor cells is particularly interesting. We know that these blood channels have exceedingly thin walls, in some instances no more than the single layer of epithelium making up the blood channel.

We know how intimate is the relation in the normal lung between the lymphatics and the epithelium, and how easy it is for cells to go through that very thin tissue.

Dr. Pfahler's remarks I think fit in very well with the Symposium, and it is a part of the subject which should be thoroughly well understood. The procedure of introduction of air into the bladder, in cases of tumors of the bladder, is not without a certain amount of risk. All urologists realize that there is a very definite rate of mortality connected with this procedure and that it must be done with due regard to that mortality, and with great care.

There is, of course, another way of making the examination—by the introduction of opaque substances, such as sodium iodide, into the bladder. But my experience has been, as Dr. Pfahler's, that you get a little more information by the introduction of air than you do by the use of opaque solutions. But do not forget to proceed with great discretion in the introduction of air into the bladder.

DR. SAMUEL BROWN (Cincinnati, Ohio): I take exception to one reference in the excellent paper by Dr. Lower. If X-rays are good in inoperable cases, why are they not good in operable cases? I get better results

in certain cases than in others, and I attribute the good results to the fact that those patients did not get the benefit of the knife. Those who were operated on did not do as well; those who were not operated on seemed to do better. I think that the knife often spoils the field for X-ray treatment.

DR. GRAHAM (closing): A subject has been brought up into which I did not go as far as I would have liked to do—about the invasion of blood vessels—and it may explain some of the unexpected metastases. A tumor which is encapsulated, irrespective of whether it is carcinoma or sarcoma, shows little tendency to dissemination so long as it is within its own capsule. It may disseminate through the blood stream because of the relation of the tumor cells to the blood stream. But any tumor which breaks through the capsule has, then, two routes of dissemination: by reason of its original relationships it may go through the blood stream, and by reason of the lesion it has access to the blood stream.

SPONDYLITIS TRAUMATICA TARDA (KUMMELL'S DISEASE)[1]

By EDWARD S. BLAINE, M.D., F.C.R.S., CHICAGO, ILLINOIS

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THE name "Kummell's disease" has been given to a specific X-ray and symptom complex first described by Kummell in 1891 (1). Other terms include appropriate and descriptive phrases which indicate the pathologic change, the causative factor, and the characteristic delay of symptoms, namely, "post-traumatic spondylitis," "spondylitis traumatica tarda," and "post-traumatic vertebral collapse."

Attention is being directed to this peculiar condition by medical writers and investigators with increasing frequency in Germany, France, and in America, which may be construed as evidence that the lesion is not so rare as some surgeons and roentgenologists believe it to be. However, it is safe to say that it is an uncommon condition and that it occurs so seldom that many busy roentgenologists have never encountered a typical case, or, at least, never have been confronted with the chain of events which characterize Kummell's disease.

An X-ray study of this condition reveals varying degrees of loss of bone substance of a vertebral body at different periods of time following causative injuries which range from the seemingly inconsequential to trauma of major proportions but without actual gross compression fracture. The typical case presents an unmistakable clinical and roentgenological complex, while the atypical ones are less easily recognized and consequently are frequently overlooked. It is my opinion that there is a considerable number of unrecognized cases of Kummell's disease, a belief which I base on the fact that I am discovering the characteristic X-ray shadow evidence of a partial collapse of a vertebral body without history of fracture when searching for X-ray evidence of non-traumatic conditions. This has come about, in part at least, by the adoption of an exposure technic in my laboratories of lateral films in all routine chest examinations, of lateral views of all gastro-intestinal examinations, as well as the usual lateral projections of all spine cases such as are now a routine procedure in all modern X-ray laboratories staffed by skillful roentgenologists. On a few of these lateral projections I have found the typical shadows of vertebral bone changes which characterize the condition under consideration. Most of these are symptomless and the patient is not aware that one of the spinal bones is partially collapsed.

This lesion was first described by Hermann Kummell, in 1891, followed by subsequent writings since that time, and his name is usually cited in referring to the condition. A not inconsiderable literature on the subject has accumulated, among the writers who have contributed being Bahr (2), Bäumler (3), v. Bechterew (4), Berkhoff (5), Duclaux (6), Ewald (7), George and Leonard (8), Hagemann (9), Jones (10), Kocher (11), Köhler (12), Nonne (13), Rossi (14), Schlatter (15), Steindler (16), Verneuil (17), and Zamboni (18). In 1891, Prof. Hermann Kummell (1), of Hamburg, presented his noteworthy work on a new condition which he called "die rarefizierende ostitis der wirbelkörper" (rarefying osteitis of a vertebra). He described the lesion as of traumatic origin, such as a blow on the shoulders or back or the neck, or on top of the head, with a resulting pressure or squeezing of one of the

[1]Read before the Radiological Society of North America, at the Fifteenth Annual Meeting, at Toronto, Dec. 2–6, 1929.

mid-vertebræ but with no gross fracture. The injured individual does not experience local pain in the back at the time. After two to three days he begins to complain of back pain, which sooner or later disappears for a time, again to return months (or perhaps years) later. At this late day the condition appears to develop as a neurological problem, with complaints of pain extending from the back along the intercostal nerves or down the lower limbs, depending on the level of the involved vertebræ. An X-ray study now discloses an unsuspected partially collapsed vertebra. Kummell called attention to the occurrence of relatively slight force in the production of the lesion in many of the cases that he reported, a trauma that under ordinary circumstances would not result in fracture of such a bone as a vertebral body. In 1921, thirty years after his original thesis, Kummell (19) reviewed the subject *in extenso,* changing the terminology to "Die post traumatishe Wirbelerkrankung," or "post-traumatic disease of a vertebra."

Three stages of the development of the lesion may be described, as follows: first, the occurrence of the injury, often of minor degree, with no evidence, X-ray or otherwise, of a fractured vertebra, with relatively little pain for a short time; second, a period of normalcy with no complaint of pain, etc., and third, usually after several weeks, sometimes after several months, though occasionally after several years, the gradual development of back pain and, in a few cases, a moderate prominence on the spine. An X-ray study at this time discloses an altered vertebra, the body of which is decreased in volume, in other words, is partially collapsed. Schede (20), in 1912, referred to a similar condition and considered it as a slowly developing bone change—the result of an unrecognized fracture, with a resulting gibbus, but Kummell believes that no actual or true bone fracture occurred at the initial injury. He regards it as an injury, possibly microscopic in extent, to the trophic factors, which are so affected that they no longer can function in a normal manner, and as a result the bone tissue becomes more or less devitalized and unable longer to withstand the pressures incident to normal postures. The most frequently involved vertebræ are those from the fourth to the seventh dorsal, but the lesion has also been found in the lower dorsal and the upper lumbar bones, and Colcher (21) has reported one of a sixth cervical vertebra.

The principal feature in the discovery of a case of spondylitis traumatica tarda is the finding roentgenologically of a more or less collapsed vertebral body, often without kyphos or knuckle, it may be incident to an examination for non-traumatic lesions. There is often no recollection on the patient's part of a severe back injury, but in other cases there is a history of such an event several months to several years previously, often not of enough severity to have put the patient to bed or call for more than casual medical attention. Such injuries consist of a more or less severe squeezing force to the upper and lower parts of the patient's body in hyperflexion. The bone collapse was not present immediately after the injury, as shown on X-ray examination at the time, or, in the absence of such X-ray examination, as based on the absence of clinical evidence of a fractured vertebra.

Many patients who have this lesion do not know that they have actual bone change, while other individuals think of themselves as having lumbago, or the like. Many do not have any symptoms referable to the collapsed vertebra at all, and go through life without ever being inconvenienced by it or knowing of its presence. The symptomless cases of collapsed vertebra are discovered during X-ray examination for some condition not associated with the spine, such as investigation of the urinary tract or the chest for respiratory or heart disease.

The particular cause of the changes which

characterize this lesion appears to be a trauma to the trophic supply of an individual vertebra by which this vitally necessary mechanism is prevented from functioning, thereby disturbing the normal process in maintaining the integrity of an individual bone. In other words, the constantly present process of wear and repair which is normal throughout our physical bodies, is literally put out of commission at a local point, in this instance a single vertebra. This, then, is followed by the absorption of devitalized bone cells in greater or lesser amount, in accordance with the amount of trophic injury incurred. Lacking the repair process, an absorption of the devitalized bone takes place, the volume of the bone decreases, and the result is a lessening in the size (volume) of the body of the involved vertebra. This we see on the X-ray film as shadows that represent a "settling" process, demonstrated by the decrease in height. The decrease in bone volume is greater anteriorly than posteriorly in some cases, not unlike the changes which occur in tuberculous spondylitis, and a similar gibbus results. However, in a few of the cases this decrease is fairly uniform throughout the body of the vertebra, the settling occurring evenly with no gibbus resulting. In certain cases of lumbar involvement there is only a flattening of the normal lumbar curve forward, while some dorsal cases show only an accentuation of the dorsal prominence. The normal support of the posterior processes—the articular facets, etc., of vertebral anatomy—retards the settling process, which accounts for the greater loss in the forward portions of the body in the cases in which a knuckle develops. The X-ray shadow outline of the involved vertebral body has changed from that of a fairly regular parallelogram to that of a truncated cone, which is graphically shown on the lateral X-ray projection in such cases. Incidentally, it is to be remarked that this lesion is seldom recognized on the antero-posterior X-ray projections, even on technically perfect films, but after finding the lesion on the lateral projection it will be recognized and supported by shadows on the antero-posterior views, particularly on stereoscopic visualization. The distortion incident to all X-ray projection has to be considered in analyzing the shadows of the bones of the spine which fall near the upper and lower edges of the 14x17 films, which usually are used in routine spine examinations since the advent of the Potter moving grid. Those bones farthest away from the central point of exposure will show a considerably greater degree of distortion, due to the increasingly divergent rays, and may offer difficulties in interpretation. If lateral projections are not a routine procedure, one will miss the lesion under discussion. It is the lateral projection on which we must place our dependence in the search for Kummell's disease. The use of the Potter grid makes successful lateral exposures of the spine easily possible, and this examination is now a much less formidable operation than formerly.

Pathological studies of this lesion are reported by Ludloff (22) as showing the presence of numerous small hematomas in the spongiosa of the involved vertebral body, with rarefaction of the bone tissue seen in the moderately advanced cases, while in late cases there is a complete breakdown of the bone structure. Microscopic studies by another observer have been reported in a case which showed an intervertebral disc, associated with the involved bone, also to have undergone a similar process of nutritive starvation through traumatic obliteration of the blood vessel and trophic supply. This was recorded on the X-ray film by a decreased intervertebral space. In a few cases, it appears that one intervertebral disc only is involved, no bone collapse having occurred, but in such instances the symptoms are more vague and there is consequently a paucity of premises on which to base a conclusion. In

this form the intervertebral disc decreases, permitting the two apposing bones to approach each other, yet the space does not entirely disappear as it does in high grade inflammations. In one case observed by the writer such an inflammation appears to have occurred as a complication or sequel to the development of Kummell's vertebral collapse.

A striking feature of post-traumatic spondylitis tarda is the surprisingly small degree of disability that results in most cases. In fact, if true disability were to occur, I would question whether it were a case of Kummell's disease. Steindler (16), in his recent work on the spine, states that the prognosis in "Kummell's kyphosis," as he terms it, is usually good, and that permanent disability is rare, a partial disability of from 10 to 15 per cent being most frequent.

As has been previously stated, a careful study of X-ray films of good technical quality shows normal vertebral bones immediately after the injury which later develops into a Kummell's disease. It is evident, therefore, that this condition is not a fracture of a vertebra in the ordinary sense. Whether or not microscopical compression is the initial lesion remains a question, but obviously the X-ray cannot demonstrate such an occurrence. George and Leonard (8), in their book on the spine, differ with Kummell as to the absence of initial fracture, believing it to be definitely a compression fracture, overlooked on the X-ray film after injury. I am inclined to this hypothesis, but consider it a microscopic rather than a macroscopic solution of continuity of bone structure, with trophic injury and subsequent degeneration of bone substance, absorption, and collapse. One discussant recently submitted the hypothesis that Kummell's collapse does not occur unless the bone is already diseased at the time of injury, suggesting that a latent focus of infection was a prime factor.

The principal lesion to be differentiated from Kummell's disease is spondylitis tuberculosa. In this condition there is suppuration, necrosis, and much more absorption of bone tissue than is usual in Kummell's disease, the gibbus is invariably much more pronounced, and the condition is vastly more painful. In fact, many cases of Kummell's disease do not develop a knuckle, the loss being more even throughout the bone, which results in a more even settling.

In spondylosa rhizomelica there is a general settling of all of the vertebral bodies, resulting in a decrease in height more marked anteriorly, but this is not confined to one bone as is the case in Kummell's disease.

In the post-typhoid spine there is some loss of bone substance, but usually a hypertrophic change of repair takes place, covering the local decrease. In some of these cases an intervertebral disc may be involved —and destroyed, permitting direct apposition and fusion of neighboring bones.

In malignancy of the spine there is a local disappearance of bone density, but a shell-like outline of a vertebral body tends to remain and retain its usual size until it collapses from the superimposed weight of the upper body. In metastatic malignancy there are multiple small rounded areas of bone disappearance such as are never seen in Kummell's disease.

In syphilis of the spinal bones there is an increase of bone and periosteum, the opposite of the change seen in the condition under consideration. In Charcot's spine there is very marked disintegration of bone, while usually more than one bone is involved, resulting in an intermixture of the pathologic and normal quite unlike the localized and more clear-cut shadows seen in Kummell's disease.

In osteomalacia the changes are not confined to one bone of the spine, but are found in all the skeletal structures—a uniformly diffuse change.

CASE REPORTS

The first case of this condition that came to the writer's attention was that of H. W., a member of his family, a woman 60 years of age who had experienced periods of low back pain for many years, although she made no complaint of the matter. The pain and discomfort were noticed immediately after changing the body position, following a period of rest or inactivity, notably on rising in the morning. After moving about, the back pain usually disappeared during the day. Bending the spine was not painful but was attended with some degree of discomfort, so that there was evident some limitation of flexibility, which, however, was more voluntary than actually restricted. She was not greatly concerned about the matter, only casually asking me if the X-ray would show the reason that her "back was sore at times." Upon making X-ray films of the lumbar spine I found a very marked settling of the body of the second vertebra. There was no spreading of the bone, no callus repair, or other evidence of fracture. There was only a decrease in the height of this particular bone, the others being normal; the cancellous bone architecture was lost. On going back over her history, I found that some thirty or thirty-five years previously, in the era of horse car transportation, while she was about to board a street car, as she raised her foot to step up into the body of the car from the rear platform, the horses lurched into their collars in getting the car started into motion. The sudden start caught her off-balance on one leg and she sat down suddenly with a jolt. She was assisted to arise and helped to a seat by the conductor. Aside from the jarring which she received she did not notice much discomfort, proceeded to her intended tasks, and later in the day returned home. Her back was sore but this disappeared after several days. After a considerable period of normalcy (several weeks), the pain returned. This became so



Fig. 1. Case 2. Unmistakable X-ray evidence of a collapsed first lumbar vertebra which must have antedated the recent injury by a considerable period of time, probably years.

bad that she remained in bed for about a week, albeit without medical attention. Following this, the pain gradually disappeared and she resumed the normal routine of a school teacher's duties. For several years all seemed well, but a gradually increasing discomfort in the lumbar region was noted, particularly on arising each morning. While it never left her entirely, it did not bother her particularly, probably through her having become accustomed to it, but there occurred periods when it was more marked than others. My X-ray examination of her lower spine showed the second lumbar body to have decreased in height approximately one-half the normal size. It was an even



Fig 2 Case 3 No shadows of callus formation are seen in any part of the dorsolumbar spine . . From the X-ray standpoint the features are quite those of a Kummell's disease

settling, all portions of the body being equally involved. Thus there was no triangulation of the vertebral body such as has been found in many of the reported cases The condition continued, with remissions as before, until her death from nephritis.

Another case (No. 2) is that of a patient (Fig. 1), W. B, male, white, age 26, 137 pounds in weight, who came to Wesley Memorial Hospital on Dr. Paul Magnuson's service, complaining of pain in his back, which extended down the back of both thighs. He stated that several weeks previously he had fallen down an iron stairway. He found it a little difficult to straighten up when he regained his footing, because of bruises and muscle soreness in his back, but walked home unaided Application of a hot water bag relieved the moderate pain so that he could resume his work the next day. After some time the discomfort and soreness in his back bothered him and he wanted something done to relieve it. After a study of the case a tentative diagnosis of severe wrenching of the back, with possible injury to the sacroiliac joints, was made. An X-ray investigation showed no evidences of a recent injury such as fracture or dislocation, but did show evidence of an old change in the body of the first lumbar vertebra. This was seen as a considerable decrease in the volume of the bone, its height being noticeably less than that of the neighboring bones, with a slight truncation but no angulation or gibbus. In view of his occupation, that of a laborer, it seems proper to consider this as an old, hitherto unrecognized case of Kummell's disease disclosed by the X-ray evidence. The man never has had a back injury severe enough to require surgical attention, has never been confined to bed for back trouble, yet there is unmistakable X-ray evidence of a collapsed first lumbar vertebra which must have antedated the recent injury by a considerable period of time, probably years

A third case (Fig. 2) is that of A B, white, male, 52 years of age, who came to Frances Willard Hospital, referred by Dr. A. F. Stewart. He complained of low back pain. Six months previously this patient had been in an automobile accident, the car turning over. He was knocked unconscious and "came to" in a doctor's office. He had been struck over the head in the temporal region and the skin over the lumbar region was bruised. After restoratives had been administered and dressings applied to the bruised parts he walked out of the doctor's office, was taken home and put to bed, remaining there for four days. He felt weak but could walk without much difficulty and had no pain except a little in the lumbar region, which gradually subsided and disappeared entirely in about two months' time



Fig 3 Case 4. X-ray study showed no evidence of bone fracture or dislocation but disclosed a typical alteration of the body of the sixth dorsal vertebra, which is materially smaller than the bones above and below it The evidence was such that a report of Kummell's disease was made



Fig 4 Case 5 An X-ray examination of the spine disclosed the decrease in height of the first lumbar vertebra, indicating a collapse The X-ray shadows are rather more like those in the ordinary compression fracture than is true of the usual post-traumatic case, but the fact that the symptoms did not manifest themselves until nearly three months after the injury seems to warrant its being classified as an atypical Kummell's disease.

He could then bend his back in any direction without pain. After about two months of normal ease, the pain in his back returned, from which he sought relief upon entering the hospital. (Incidentally, a lawsuit was in the offing.) An X-ray examination was made (September 28, 1928), with the following report: "The body of the first lumbar vertebra is collapsed to less than one-half its normal volume. It is evidently an old lesion No signs of bone fracture are present All other bones are normal. The shadows are consistent with a Kummell's disease" One consultant regarded the case as one of a compression fracture, so a second examination was made after an interval of three months (January 31, 1929), and reported as follows: "No shadows of callus formation are seen in any part of the dorso-lumbar spine The 'settling' of the body of the first lumbar vertebra, reported on my previous examination, is again manifested, the condition being substantially the same. From the X-ray standpoint the features are quite those of a Kummell's disease"

A fourth case (Fig. 3) is that of S. L., white, male, age 42, who was sent to me at the National Pathological Laboratories by Dr Karl Meyer, complaining of pain in his back This man had been in a fight some time previously, and he had twisted and strained his back in throwing his opponent. His back had been painful for two or three days but this left him and he went to work. Some time later he began to feel pain along his spine on movement in bending and in climbing stairs. His physical examination was negative. An X-ray study showed no evidence of bone fracture or dislocation, but disclosed a typical alteration of the body of



Fig 5 Case 6 X-ray examination disclosed a lesion involving the twelfth dorsal and first lumbar vertebræ The bodies of both of these bones were fused on their apposing surfaces, with a marked decrease in the height of only the twelfth dorsal



Fig 6 Case 7 This X-ray examination fails to reveal any evidence of recent bone or joint injuries but does disclose the presence of an old lesion of the eighth dorsal vertebra This consists of a partially collapsed body of the bone and is definitely an old rather than a recent lesion

the sixth dorsal vertebra, which was materially smaller than the bones above and below it. The evidence was such that a report of Kummell's disease was made No X-ray examination had been made immediately after his injury, so that we do not know whether or not the lesion was present at that time, but if he had had a compression fracture it is highly improbable that he would have returned to his work with a "broken back."

Case 5 (Fig 4). J. F., age 33, 145 pounds in weight, 5 feet 9 inches in height, entered Wesley Memorial Hospital on the service of Dr H. M Richter. On May 26, 1929, the patient fell about fifty feet, landing on his feet The fall resulted in an injury to the left foot which, upon X-ray examination, was found to be a comminuted fracture of the os calcis No complaint was made by the patient of any particular trouble in his back, which, therefore, was not examined roentgenologically Because of the foot injury he was confined to bed in the hospital for several weeks At no time did he notice any pain in his back until five weeks after the injury, when he was allowed to be up and around. For the next few weeks he noticed some slight pain and rather marked numbness in the dorsolumbar region. This numbness occurred only when the patient was sitting down. Since its onset it has been becoming progressively worse. Because of this complaint of his back, an X-ray examination of the spine was made (August 10, 1929), three months after the injury, in order to satisfy the patient. This disclosed the decrease in height of the first lumbar vertebra, indicating a collapse. The

X-ray shadows are rather more like those in the ordinary compression fracture than is true of the usual post-traumatic case, but the fact that the symptoms did not manifest themselves until nearly three months after the injury seems to warrant its being classified as an atypical Kummell's disease, with actual fracture of slight degree as the initial injury, with subsequent progressive vertebral collapse.

Case 6 (Fig. 5). N. T., age 64, weight 165 pounds, 5 feet 5 inches in height, referred August 8, 1929, by Dr. Karl Meyer for an X-ray study of the gastro-intestinal tract. During this examination there was noted a lesion involving the twelfth dorsal and first lumbar vertebræ. The bodies of both of these bones were fused on their apposing surfaces, with a marked decrease in the height of only the twelfth dorsal. Upon questioning the patient he gave a history of a back strain at the age of 16. He said this injury resulted from heavy lifting and was of little consequence but that he did have mild pain in the back for a period of several weeks, not enough to cause him to consult a doctor. He did not recall any other incident which would point to an injury to the spine such as would produce the changes found. He has had no symptoms of spinal trouble since the incident of about fifty years previously. In this case the evidence denotes an accompanying injury to the intervertebral disc, which also underwent a softening process, with subsequent absorption and the probability of an inflammatory accompaniment in the cartilage.

Case 7 (Fig. 6). This patient, J. R., is a male, 23 years old, white, a carpenter by occupation. He was admitted to Wesley Memorial Hospital on Dr. Sumner Koch's service on March 1, 1929, having just been hit by a street car. He was considerably bruised over the hips and there was much loss of skin over the thighs and left knee. An X-ray examination failed to reveal any evidence of recent bone or joint injuries but did disclose



Fig. 7. Case 8. X-ray investigation of most of the bones of the body disclosed only one abnormal area, that of the twelfth dorsal vertebra, the body of which presented a typical truncation of a partially collapsed vertebra. The shadows did not have the appearance of a malignancy, nor did they present the usual shadows of a post-typhoid spine. The evidence was largely in favor of a Kummell's disease.

the presence of an old lesion of the eighth dorsal vertebra. This consisted of the partially collapsed body of the bone and was definitely an old rather than a recent lesion. An incomplete history as to any previous injuries was obtained, but it is obvious that no vertebral bone can undergo such a collapse without there being some cause. This might easily be some minor trauma that anyone who goes through our modern life hazards is liable to experience, without its focusing the attention of the individual to any particular event. One has but to recall the strains and stresses incurred by students at high school, college, etc., in playing foot-



Fig. 8. Case 10 The X-ray findings are a partial collapse of the body of the seventh dorsal vertebra Although marked truncation is present, there is no gibbus or prominence over this level. This seems to be a typical case of Kummell's disease

ball, etc., to appreciate the possibilities in this case.

Case 8 (Fig. 7). This patient, E. W., white, female, 54 years of age, 106 pounds in weight, was referred by Dr. Christian Hauch on March 29, 1929, for X-ray study of the spine. There was complaint of pain and tenderness over the lower dorsal area. Two years previously she had stumbled over a raised board in the sidewalk, and fallen, straining her back rather painfully but not severely enough to require rest in bed. After a time the pain disappeared only to return later. For the past year she had complained of varying degrees of pain in the mid-spine. As she had had one breast removed four and a half years previously and the other two years later for malignancy, a metastasis to the spine was suspected as the cause of the pain of which complaint was made. She also had had typhoid fever some twenty-five to thirty-five years previously. An extended X-ray investigation of most of the bones of the body disclosed only one abnormal area, that of the twelfth dorsal vertebra, the body of which presented a typical truncation of a partially collapsed vertebra. The shadows did not have the appearance of a malignancy, nor did they present the usual shadows of a post-typhoid spine. The evidence was largely in favor of a Kummell's disease.

Case 9. Patient was J. Y., white, female, 28 years of age, 125 pounds in weight, referred by Dr. C. M. Jacobson on January 19, 1927, for X-ray examination of the lumbar spine and sacro-iliac joints. Her complaint was that of recurring periods of low back pain. For weeks at a time she was free from her trouble, but at times it became quite uncomfortable. It was most noticeable on arising in the morning. There was no history of a recent injury but eleven months previously, while being taken to a railway depot in a taxicab, the cab struck a hole in the pavement, and on the rebound she was bounced upwards, striking her head against the ceiling of the cab. The chauffeur immediately stopped and inquired the extent of her injury. She complained of her head hurting, but went on to the depot, making no mention of her back. She continued her journey, a three-hour train ride, during which time she had a good deal of headache. This continued for several days. Two or three weeks later she began to notice a sore spot in her back, but this did not bother her to any great extent. Later on, whenever she rode in an automobile or street car, she found that the pain in her back would return. The X-ray examination established the presence of a partially collapsed body of the first lumbar vertebra. There was moderate truncation of the bone but no gibbus or undue prominence. On this X-ray evidence and

the history, the findings are those of a traumatic spondylitis tarda.

Case 10 (Fig. 8). This patient was M. A., a female, 40 years of age, 135 pounds in weight, referred October 18, 1928, by Dr. R. W. McNealy to determine the cause of a pain between the shoulder blades. Five months previously, while riding in an automobile on a wet day, the car failed to make a turn and left the road, crashed through a retaining fence and rolled down a 20-foot embankment into a ditch. She was unconscious for a short period and "came to" standing on her feet supported by members of her party. Immediately after the injury her neck felt stiff but otherwise she made no complaints. Weeks later she began to notice some pain in the mid-dorsal region when on her feet, and for nearly a year she experienced pain in breathing on deep inspiration. This gradually subsided and since that time she has had no symptoms whatsoever. The X-ray findings (October 18, 1928) are a partial collapse of the body of the seventh dorsal vertebra. Although marked truncation is present, there is no gibbus or prominence over this level. This seems to be a typical case of Kummell's disease. A re-examination made by me on October 1, 1929, shows the condition to be exactly as at the previous one.

SUMMARY

Whatever the exact etiology may be, Kummell's disease, or complex, is a lesion that is of considerable importance to the industrial physician and surgeon and the roentgenologist.

There is some probability that the initial lesion is a minor degree of compression of a vertebral body, but careful X-ray examinations of the spine made immediately after injury show no fractures of the vertebra that on later X-ray study is found to be decreased in height, indicating a partial collapse.

There can be no doubt but that some cases, diagnosed as Kummell's disease, were simple compression fractures overlooked on X-ray examination or not roentgenographed at all.

There is a fairly constant sequence of events which characterizes this condition.

It is not a disabling disease and may be symptomless.

The X-ray is the only means by which its presence may be revealed.

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DISCUSSION

DR. W. W. WASSON (Denver, Colo). In view of the hesitancy of the audience in discussing the papers, I would like to report a case. I do not wish to be placed in the position of reporting the impossible, but I do believe that it probably offers one or two points to Dr. Blaine's paper. In the spine we have many vertebræ. There are certain points in that spine where a force, when applied to the spine, gives the greatest trauma to the vertebra—certain crucial points. It is also reasonable to assume that all of the vertebræ will not have the same strength. This case that I wish to report illustrates that possibility. A parachute jumper left his plane at three thousand feet. He weighed one hundred and seventy-five pounds. He had a twenty-eight foot parachute. The parachute opened only three feet. According to calculations, this was sufficient to break the fall of only twenty-five pounds. We, therefore, have a one hundred and fifty pound man falling from a three thousand foot altitude. The man fought the rope all the way down. He lit on his toes. He was a professional parachute jumper, and knew what was going on at all times, even when he struck the ground. He lit on his toes and was jackknifed. According to the calculations of the timers, the observers, this man was travelling at the rate of two miles per minute when he struck the ground. His toes entered the ground four inches. Blood spurted from his nose and mouth. He was unconscious for some thirty days. He was in the hospital for some two or three months. He walked into my office with a cane a few months later for a radiograph of his spine. Very much to my surprise there was not a great deal of displacement of any of his vertebræ. He had a compression fracture of the second lumbar and two thoracic vertebræ with a perfectly sound vertebra in between the two compressed fractures of the thoracic vertebræ. This seems to me to bring up the point that certain ones of his vertebræ must have had less strength than the others.

DR. H. P. DOUB (Detroit, Mich.): This subject which Dr. Blaine has brought up is a very timely one indeed because of its economic importance and because of the fact that it is, or has been until recently, rather imperfectly understood. In fact, the origin of this is not as yet clearly defined. I believe that it behooves us as roentgenologists to insist upon a standard technic for examination of the spine so that we may obtain records of these cases, and also protect the patient against a long disability. The first thing that we should insist upon is a lateral view of the spine with sufficiently good technic to show the bodies of the vertebræ clearly. These cases of injury to the spine which at first show no evidence of bone injury, and which later show narrowing of the bodies of the vertebræ, may result in considerable economic loss because of inability of the patient to do his work.

The cause of this, as Dr. Blaine has explained, is not entirely clear. So far as I can find out in the study of the literature, etc., it would appear to be some nutritional or trophic disturbance due either to injury to the blood supply or nerve of the affected vertebra. One instance has been reported in which an injury case came to postmortem examination. Evidence of considerable injury to the blood vessels supplying the bodies of the lumbar vertebræ, which were narrowed, was seen.

Senile kyphosis, as mentioned by Dr. Blaine, gives somewhat the same picture. There is rather marked osteoporosis. With the marked kyphosis there is a tremendous crushing influence on these vertebræ, which may enter into the etiology or which may accentuate the condition.

DR. BLAINE (closing): The essential point of the story is that in Kummell's dis-

case we are dealing with a change that develops slowly, usually long after an initial injury. We cannot classify as a case of Kummell's disease any case that shows an immediate compression fracture, such as Dr. Wasson has shown us. His interesting case may add one point to what has been suggested in the paper, namely, that the collapse of a vertebra in the manner shown probably occurs in a body that has a lessened resistance, and in which there was probably a minor degree of inflammatory change which weakened this one particular bone—the one to give way to the force which the normal vertebræ resisted. A chain is no stronger than its weakest link in mechanics, and this is probably equally true in bone resistance of the spinal column.

Moral and Physical Aspects of the X-ray Film Storage Problem. Charles E. Remy. Modern Hospital, April, 1930, XXIV, 59.

Why X-ray Films should be Preserved Indefinitely. Ramsay Spillman. Modern Hospital, September, 1930, XXXV, 63.

A fair judgment of the arguments advanced by the writers of these two papers depends upon the reading of both, or, as *Modern Hospital* editorially states, " 'There are two sides to every question,' and it is only by a frank discussion of both sides that the ultimate truth may be uncovered."

The first writer advances arguments for the destroying of the great bulk of an institution's films, claiming that the medical staff is responsible in the main for the retention of them beyond a limited period, under a delusion that "some day it will have the time to study these thousands of old X-ray films." He adds: "It has been my observation . . . that after the lapse of even a year, the physician, in studying the patient's past history in relation to his present complaints, depends almost exclusively upon the report of the roentgenologist, rather than upon the film and its interpretation." Dr. Spillman, in his article, does not allow these statements to go undiscussed.

Writing of acetate films, Dr. Remy makes the admission that he has taken the word of "the representative of a prominent fire underwriters' association" that "he did not know whether or not these films would give off poisonous fumes in case of serious fire." These need not be matters of surmise and hearsay, since they have been scientifically investigated and reported upon, as, for instance, "Safeguarding the Storage of Photographic, Motion Picture, and X-ray Films," by C. R. Brown, Assistant Physicist of the Bureau of Standards, Washington (RADIOLOGY, May, 1930, XIV, 454).

In Dr. Spillman's reply he analyzes the reasons why a physician may need to re-examine films as a case develops, how an adequate index may make films in storage available for reference without necessitating the handling of those not wanted, and a study of the properties and economics of films.

M. INGLEHART.

VERRUCA PLANTARIS[1]

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VERRUCA plantaris is an entity frequently not recognized; when observed, it is often classified as a plantar callus because of the coincidence in some instances of a considerable amount of keratosis. Since we have been on the alert for this manifestation, it is surprising how commonly it is found. The number of cases now being brought under observation is increasing rapidly, since this condition has been called to the attention of the student health departments of schools and the medical inspection service of institutions fostering gymnastic activities.

Radiologists and dermatologists are beginning to attach more importance to various types of callosities of the feet than they did four or five years ago when very little was written on the subject. Although verruca plantaris apparently is unimportant, the frequency with which pain and sometimes occupational disability occur in these lesions justifies the interest taken. From our experience and from a study of the recent literature, we have concluded that the cause of verruca plantaris is an infection, contagious to the extent that its prevalence approaches endemic proportions.

The cause of the lesions has not been determined, so far as I know, but its dissemination appears, from our study of fifty-three cases, to have a distinct relation to use of the same gymnasiums, shower baths, and swimming pools. I recall the simultaneous occurrence of plantar warts in three members of a family in daily contact with the same shower bath, and in six students from a sorority house who used the same shower bath.

Control of the dissemination of verruca plantaris does not appear to be easily accomplished. Various modes of disinfection of floors where persons walk with bare feet have been practised without any measure of success. Wearing slippers is quite effective, and the condition is being controlled by this means in some institutions.

The diagnosis of verruca plantaris is simple, but care should be taken not to confuse it with the more common callus seen on the feet. Our early interest in distinguishing verruca plantaris from these callosities was from the observation of extensive keratosis, studded with the characteristic translucent areas, at sites where the irritation of weight-bearing or the pressure of ill-fitting shoes did not exist. There is a period in its life history when the verruca does not show the pin-point dots described by Taussig and Miller (1). In this stage it probably is inactive and, unless involved in extensive callus that is constantly irritated, it is not sensitive to pressure and the patient does not realize its presence. In a few of our cases the history of these warts extended over several years, with periods of activity which subsided and again became active with pain on pressure.

Verruca plantaris usually occurs on the anterior half of the feet. In three of our cases the lesions occurred on the heels; the toes were involved in six cases. All other locations were on or near the transverse plantar arch. Two patients presented multiple lesions evidently consisting of one parent location with more than twenty-five secondary lesions widely disseminated over the anterior half of the plantar surface. Eight had discrete verrucas, three a single lesion, and the remaining number two or three discrete verrucas.

Our study of fifty-three cases successfully

[1]Read before the Radiological Society of North America at the Fifteenth Annual Meeting, at Toronto, Dec. 2 to 6, 1929.

treated by X-ray has convinced us that the condition is not limited to age, sex, color, race, or occupation. The ages in this series varied from eight to forty years. There were forty-six females, which included thirty-three students, three white and two colored domestics, three stenographers, two cashiers, and three nurses; seven men, including two doctors, one minister, one jockey, two students, and one colored janitor.

Three of our patients had had three treatments with electrodesiccation three months previous to X-ray treatment; they complained of pain with electrodesiccation and the result was unsuccessful. One patient had had one radium treatment of an hour's duration, without noticeable results. We have observed the surgical treatment in three cases; the result was satisfactory but the convalescent period was long and was associated with considerable pain and some disability. With the exception of two cases, pain was relieved after the fourth day following the first X-ray treatment and the convalescent period was about four weeks; the longest period was seven weeks, at which time all evidence of the growth had disappeared.

Our technic is a dose twice the time required to produce a mild erythema on the flexor surfaces, with unfiltered radiation limited to the bounds of the lesion, followed, if required, in three weeks by a dose of one and one-half erythema intensity. In only two cases was it necessary to give further radiation—the greatest number of treatments was five in a single case. In none of our cases was there a period of disability. Many of the patients mentioned that the sites treated were slightly tender to pressure for a day or two, several days after the first treatment.

CONCLUSIONS

1. Verruca plantaris is a more common disease than is generally recognized.

2. It is caused by an infective agent and is contagious.

3. Because of the complete cure of the disease without pain or disability, X-ray treatment is the method of choice.

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DISCUSSION

Dr. W. W. Belden (New York): It is rather embarrassing for me to discuss a paper on therapy when I see here such eminent therapists as Dr. Remer, of New York, our Chairman, and others. However, I was pleased to hear Dr. Sisk's paper and I think he covered the subject very completely indeed. There is only one point I should like to bring out, that, in our experience, both in the office and at the hospital, we have found there is one technic which has been efficacious—a combination of the so-called superficial and moderately deep therapy; in other words, the filtered and unfiltered radiation. We use the following technic: Shielding down carefully around the lesion with lead, we apply a 6-inch gap, 3 ma. of current, 2 min. exposure time, at one-eighth inch distance. These figures work out, according to the formula of Witherbee and Remer, to one unfiltered unit. We then change our setting to a 9-inch backup spark gap, with 5 ma. of current, 3 mm. aluminum filter, at a 10-inch distance, and give the lesion two minutes more at the same sitting. We have found that by using this technic, the warts, callosities, etc., disappear more rapidly.

Dr. Cassie B. Rose (Chicago): I much appreciate Dr. Sisk's paper. I have treated a good many plantar warts in practically the same way as Dr. Sisk has described, and have found, as he has, that the pain is greatly relieved within two or three days. Occa-

sionally the pain returns after two weeks or so, usually not so severe as the original pain. A second treatment is given. Rarely have I needed more than two X-ray treatments to accomplish a cure. I believe that X-ray is a simple and satisfactory treatment for verruca plantaris.

DR. SISK (closing): We have not found it necessary to use any dosage other than unfiltered radiation. I should be disinclined to use filtered radiation when there is no indication for it. I had no idea of discussing technic, but the mention of it leads me to say that the milliampere-minute dose in different institutions is not uniform on account of the variation in tubes. It has been our practice to standardize a broad focus tube for superficial therapy against a skin reaction on a flexor surface. We use 100 kilovolt peak determined by sphere gap, at a skin-to-target distance of 10 inches. It is important carefully to screen with lead around the wart that is being treated.

Failure to produce results with X-ray therapy in verruca plantaris has been reported, but we have not experienced such disappointment when we have been certain that we were treating a plantar wart. We believe that reported failures of not healing warts were failures to remove a callus which might or might not have had an infected site. Calluses are much more difficult to remove by radiation than verruca plantaris, and I think there is considerable difference between a plantar callus and a plantar wart. The literature of the past two years gives sufficient information for a differential diagnosis.

SARCOMA OF THE STOMACH

By ROBERT J. REEVES, M.D.

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SARCOMA of the stomach is seldom encountered, if one may judge by the reports in the literature. Approximately 200 cases have been reported and they seem to be of more frequent occurrence than individual experience would lead one to infer. In the Berlin Pathological Institute, for instance, there is but one example of sarcoma of the stomach in the 840 specimens. In this discussion I have excluded lymphosarcoma, which is a fairly frequent finding.

Frazier, in 1914, quotes Bruch as being the first to record a case of sarcoma of the stomach, in 1847. Virchow, in 1864, referred to three cases.

Baldy, in 1893, reported the case of a patient who came to him complaining of a mass in the abdomen, which was accompanied by progressive weakness and loss of weight. Physical examination disclosed a large irregular mass filling the entire abdomen from the symphysis to the ensiform cartilage. A small hard mass, the size of a walnut, was found in the umbilicus. There had been no gastro-intestinal symptoms. Operation disclosed a large tumor protruding from the posterior wall and involving practically the entire stomach. There was no microscopical report.

Hartley, in 1896, reported the case of a woman aged 54, whose illness began five years previously with indigestion. She vomited once at that time. She had no more trouble until one year before admission, when she vomited blood on five consecutive mornings. At that time enlargement of the abdomen was noticed. At operation a large tumor of the stomach was found measuring $8 \times 10 \times 15$ centimeters. The mucosa was hyperemic but not ulcerated. A gastric resection was done and sections of the tumor showed it to be of the spindle-celled type. The patient was discharged as "cured."

Finlayson, in 1899, reported the case of a child, aged 3½ years, who was admitted to his service because of a marked anemia and failing health, of three months' duration. There was no pain or tenderness and no palpable masses. The child vomited once before admission. After admission the condition became steadily worse—profound anemia, vomiting, coma, and death. Necropsy disclosed a tumor of the posterior wall of the stomach near the cardia which measured 2×4 cm. in diameter. The mucous membrane beneath this area was ulcerated. Microscopical examination disclosed a spindle-celled sarcoma.

Haggard gives probably the most complete *résumé* of the literature and classification of sarcoma according to the microscopic appearance. He was able to obtain a microscopic diagnosis in 76 of 107 cases operated upon. According to his classification there are seventeen different varieties of sarcoma of the stomach.

Fenwick, in 1901, reported the case of a young woman, aged 22, who came to him complaining of severe pains in the epigastrium of one year's duration. The first symptoms were those of mild indigestion, gradually becoming more severe, until at the time of her visit she had lost about twenty-five pounds. Pain usually began several hours after a meal, lasting three or four hours, with no relief from food. The attacks were associated with heartburn and frequent belching of sour or tasteless gases. A hard palpable mass was present in the right hypochondrium. Operation disclosed a large intramural tumor mass occupying the greater portion of the pyloric end of the

stomach. A partial gastrectomy was performed and the pathological report was fibrosarcoma. A physical examination fifteen months after the operation showed no evidence of recurrence and the patient had gained fifty pounds in weight.

Hall, in 1928, reported the case of a young man, aged 20, complaining of intermittent pain in the abdomen three months' duration, which had no relation to meals. Physical examination disclosed a mass about the size of the clenched fist in the left hypochondriac region, extending into the epigastrium. The mass was smooth and slightly movable. Blood test showed a moderate degree of anemia. Operation disclosed a tumor mass involving almost the entire stomach and adherent to the pancreas and liver. Sections of the tumor revealed small round cells of a typically sarcomatous nature.

Douglas, in his analysis of reported cases, found that gastric sarcoma occurs in younger individuals than does carcinoma. The average age incidence for sarcoma was 41.6 years, as compared with 61.2 years for carcinoma. The youngest case reported is Finlayson's, a boy of 3½ years. The oldest was found in a man of 85 (Gosset). Although sarcoma is thought to be a disease of young adults, it seems to be more frequently found after the fortieth year.

Carnot and Lambling, in 1928, reported a most interesting case. A woman, aged 42, was admitted to the wards of the Hôtel Dieu, complaining of cardiac disturbance and showing marked anemia. For a number of months she had noticed weakness of the legs and a constant pain in the right upper abdomen, not related to the taking of food. Following this, she began having palpitation and frequent pains over the heart. A palpable mass was found in the epigastrium. Because of the cardiac condition, operation was delayed. She became steadily worse, and died. Necropsy disclosed a large tumor mass almost completely filling the right auricle. It was attached to its posterior inferior margin and had infiltrated the walls of the superior vena cava. In the stomach was a large multilobulated mass 14 cm. in diameter which had not eroded the mucosa. The microscopical studies disclosed sarcoma of the stomach and metastases in the liver, apparently extending through the posterior mediastinum into the heart.

Boyd, in his textbook on Surgical Pathology, states that, "sarcoma of the stomach is of equal frequency in men and women."

ETIOLOGY

The etiology of sarcoma of the stomach, like carcinoma, is unknown. Many believe, as does Ewing, that inflammatory changes are significant predisposing factors. The case reported by Pistocchi is interesting in that the symptoms followed severe trauma of the epigastrium. He is inclined to accept a direct connection with trauma as a causative factor.

CLASSIFICATION

Sarcomas are connective tissue growth
hence they never develop from th
membrane. According to their ti
they may be fibrosarcomas, myo
lymphosarcomas. According
classification, there are three
(1) lymphosarcoma, which is
mon, (2) round cell, and (3)
fibrosarcoma.

The round-cell type is of
gin as an infiltration of
which subsequently spread
lar coat through its int
tissue, finally destroying
tractile fibers. At first
brane is merely stretche
growth
at the lat
disease and

The spin

a round or oval circumscribed tumor of the stomach wall, situated usually near the curvatures. As the tumor grows it projects more beneath the serous coat and exerts sufficient traction upon its site of origin so that



Fig. 1. Case 1. Roentgenogram of the stomach showing the filling defect on the greater curvature.

in the later stages it not only drags the entire stomach downward but often acquires a pedunculated appearance. It is usually smooth and firm on section. As the bulk increases, it often becomes irregular in shape. Degeneration and ulceration have been found in a number of cases.

Microscopically the structure varies between wide limits. In some cases the type approaches that of a cellular myoma and the recognition of a myogenous origin is readily accomplished. The differentiation between a myosarcoma and a spindle-celled sarcoma, according to Ewing, largely depends on the attitude of the observer. He believes that many of the so-called round-celled sarcomas are of muscular origin. In some cases careful examination has revealed typical myosarcoma in one portion, spindle cells in another, and elsewhere only round cells (Moser). The arrangement of the cells in intertwining bundles is often a characteristic feature. The grouping of cells about blood vessels has sometimes suggested that the tumor arises from the walls of the vessels as in myoma uteri (Kaufman), and it has led to the diagnosis of angiosarcoma or lymphangiosarcoma.

SYMPTOMS

In a number of cases there were no definite subjective symptoms: this was especially true if the tumor was situated in the pars media and the mucous membrane was not involved. The amount of pain depends on the presence or absence of ulceration. Symptoms may vary from mild epigastric distress to the severe manifestations of carcinoma. Melena and anemia are very common findings, especially in the round-celled type. Rapid loss of weight is often observed, a loss which, however, is readily regained when the patient is put to bed on proper diet: this is especially true in the early stages. Cachexia develops more slowly than in carcinoma. Enlargement of the spleen has been frequently found. It is thought (but not proven) that some of the benign tumors may undergo sarcomatous degeneration. One such case reported is that of a patient who had had a tumor for years which was thought to be an ovarian cyst. Operation revealed a sarcoma of the stomach wall.

Metastases appeared in about 30 or 40 per cent of the cases. The round-celled type is thought to be more malignant and metastasizes more readily, whereas the spindle-celled is usually slow in growth and likewise slow to metastasize. Perforation is more common in the round-celled type.

CASE REPORTS

Case 1 (Unit No. 67,090). An Italian furniture salesman, aged 43, was admitted to the Presbyterian Hospital, New York

City, October 25, 1926, complaining of pain in the abdomen, which had been intermittent over a period of several months. He had apparently been in good health until the past four or five months, when he began to be severely constipated and to have vague cramps in the abdomen, coming on usually an hour or more after eating and relieved by sodium bicarbonate. These attacks had appeared every three or four days for several weeks prior to admission. There were no gaseous eructations or real pain. Four weeks prior to admission nausea was persistent but he vomited only once; the vomitus was said to be of a dark brown color. He gradually became worse and complained of some dizziness. Because of his nausea and gastric discomfort he could eat very little, to which he attributed the loss of fifteen or twenty pounds in weight. No tarry stools had been observed nor had he noticed jaundice. For three weeks prior to admission there had been an irregular temperature, at times reaching 104 degrees.

Physical examination was essentially negative except for the abdomen. The liver was three fingerbreadths below the costal margin. The spleen was barely palpable. There was a definite tenderness in the epigastrium, to the right of the midline. No palpable masses could be detected.



Fig. 2. Photographs of the tumor removed (Case 1). The margins are raised and project into the lumen of the stomach. The center is ulcerated.

The blood examination disclosed a hemoglobin of 15 or 20 per cent; red blood cells 1,500,000; white cells, 16,000. A blood Wassermann was negative. The stools on several occasions showed a positive guaiac test.

Roentgen examination of the lungs disclosed an old fibrosed tuberculous process in both apices. The barium meal showed the stomach to be median in position, atonic, and with very few peristaltic waves—only over the antrum. A broad, irregular filling defect was present on the greater curvature,

beginning about an inch from the upper margin of the fundus and extending over an area about three inches in diameter. There was no six-hour residue. A diagnosis of carcinoma was made, and, because of its



Fig. 3, Case 2. Roentgenogram of the stomach showing the large area of infiltration along the lesser curvature.

situation, the neoplasm was thought to be inoperable.

Occult blood continued to be present in the stools. After several transfusions the hemoglobin came up to 45 per cent and the red cells to 2,900,000. After three weeks in the hospital he felt much better and was discharged against advice. Two weeks later the pain became more severe and tarry stools were again noted.

He was readmitted February 13, with a hemoglobin of 75 per cent and a red cell count of 3,800,000. Operation was performed by Dr. Fordyce B. St. John on February 14. A tumor mass was found involving the posterior portion of the pars media, measuring $4 \times 5 \times 2$ cm. and showing an ulcerating crater 2 cm. deep. No definite regional lymph nodes could be felt. A high sleeve resection and posterior gastro-enterostomy were performed.

The pathological report follows: "Microscopical examination disclosed an interstitial growth lying between the mucous membrane and the outer coat of the muscle. The mucous membrane covers it except in the crater of the ulcer. The muscle coat lies external to it, except at one or two points where the tumor lies in the subserous tissue. Numerous bands of fibers run in different directions and tend to interlace. The fibrils of the tumor are very slender but with a van Gieson stain they are garnet, whereas the supporting collagen fibrils are a deep red. This means that the nature of the fibrils cannot be definitely determined. The cells appear rather large, elongated, with hyperchromatic nuclei. Mitoses were seen in an average of one to every two high power fields. These findings place the tumor in the group of stomach sarcomas, called by Ewing 'spindle-cell myosarcomas.' He finds metastases to the liver very frequently. This type of tumor we have followed in other parts of the body and recurrence is common, but there is no record of metastases. The prognosis for the patient should be relatively good."

Following operation the patient steadily improved and gained seventeen pounds in weight in two months. He continued to feel well until November 10, 1927, eight months after the operation, when he began to lose weight and appetite, and developed a cough. The blood count was: hemoglobin 80 per cent, red cells 5,230,000, white cells 11,400.

Roentgen examination of the chest disclosed diffuse malignant metastases. The roentgen examination of the stomach disclosed a filling defect in the upper margin of the cardia, which was suggestive of a recurrence. His condition became steadily

worse and on January 4, 1928, he died. A necropsy permit could not be obtained.

Case 2.[1] N. B., a white girl, aged 13, was admitted to the Mary Imogene Bassett Hospital, February 1, 1930, complaining of headaches, dizziness, and weakness. She had been apparently well until fifteen months previously, when she began having headaches and weakness. There had been no gastro-intestinal symptoms, abdominal pain, gas, bloating, nausea, diarrhea, or constipation. She had lost a few pounds in weight. Five days before admission the symptoms became much worse and she fainted for the first time.

Physical examination was essentially negative except for tenderness over the epigastrium.

The blood count on admission disclosed hemoglobin 28 per cent, red cells 2,000,000, white cells, 6,600. The stool examinations were repeatedly positive for occult blood.

After being placed on a diet consisting of vegetables and large doses of iron, the hemoglobin came up to 69 per cent.

Roentgen examination of the gastro-intestinal tract disclosed a large irregular filling defect, apparently beginning on the lesser curvature in the pyloric region and extending through almost to the greater curvature. A projection was present on the lesser curvature and another on the anterior wall, which had the appearance of penetrating ulcers. The duodenal bulb was well filled and freely movable.

Operation was performed, March 22, by Dr. Monroe McIver, and the findings follow. Upon opening the abdomen a large firm mass was found extending from the pylorus to about the lower third of the stomach. The firm, irregular infiltration extended on the lesser curvature, and on opening the lesser peritoneal cavity, nodular masses could be palpated on the posterior wall of the stomach almost to the cardia. There were small glands in the omentum between the stomach and the colon. Similar glands could be palpated in the mesentery of the small intestine. Sections were taken and the abdomen closed without drainage.

Microscopical report follows: "The tissue is made up of closely packed cells which vary in morphology from the round cells with scanty cytoplasm to spindle-shaped cells with distinct but by no means abundant cytoplasm. The majority of the cells are of a spindle type and only an occasional mitotic figure is seen. A few budding blood vessels are observed, but in general the tissue is not profusely vascularized. Diagnosis: Spindle-cell sarcoma."

The patient made an uneventful recovery and was discharged on April 7, 1930. The blood count on discharge was: red cells 4,150,000; hemoglobin 83 per cent; white cells 5,100.

Following operation the patient was given deep X-ray therapy, to which there was some reaction. Vomitus obtained during the reaction contained no free HCl.

Examination two months later showed the patient to be apparently well.

CONCLUSION

Although primary sarcoma of the stomach is not as rare as it was once thought to be, it is still uncommon enough to warrant a careful study of such cases. The character of this neoplasm varies so widely in the different varieties, from extreme malignancy down to almost certain promise of radical cure, that attention to the possibility of its occurrence as well as to its early diagnosis, is a matter of utmost importance. The prognosis in these cases seems to vary according to the duration of the disease, extent of involvement, and type of growth. A number of cases have been reported to be well a number of years after operation, but

[1] I am indebted to Dr. George MacKenzie for the opportunity to report this case.

in numerous instances the diagnosis has been made so late in the course of the disease that operative procedure was of no avail. Where, however, early operation was undertaken, radical cure, or at least freedom from recurrence for a number of years, has been frequently obtained.

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The life of the Universal tube used in this type of work varies directly with the size of the focal spot. In all cases a deposit of tungsten is laid down on the glass of the tube, and it eventually becomes inoperative, either by reason of the filtration value of the tungsten, or puncture of the tube because of this deposit. Disturbance of the anode surface, such as melting and roughening, plays no important rôle in the dimensions of the pin-point photograph of the effective focal spot, nor does it play any rôle in the service of the tube.

The cooled type of tube with inset tungsten button anode is not so satisfactory where high kilovoltages are used. This appears to be due to the fact that these voltages melt out a spot and form a blister on the anode, causing a change in the inherent characteristics of the tubes. The exact nature of this change has not been definitely proven, although it is certainly due to a change in quantity rather than quality of radiation. Spectroscopic determinations show that the type of wave length is not affected by this condition, nor is the pin-point photograph of the focal point changed. On operation, the tube gives a brilliant illumination when high milliamperages are used. There is also an instability of milliamperage, as is demonstrated by the fact that it does not correspond to that set on the pre-reading meter. When this meter is set for an exposure of 200 milliamperes, about 300 milliamperes are produced, and it would seem that a major portion of this apparent current is used up on the production of light rather than X-rays. All milliampere readings have been made on a meter in the high tension circuit.

After this damage has taken place the tube may be used in instances in which a small output is desired, but it has no further use insofar as speed work is concerned. This condition pertains in all tubes of this type of construction, regardless of make. We have demonstrated in the case of the Universal tube that when high voltages are utilized the effective focal point is not different than when low energies are applied; but it is observed that instead of the focal area being equally affected, that portion of the anode closest to the filament receives the bulk of the rays. The target at this point shows much more wear and tear than at any other point in the focal area.

The amount of energy which may be applied to line focus tubes is extremely high when compared to a tube of the corresponding effective focal area in the Coolidge line. For example, the 20 K.W. tube, which has an effective focal point of about half the size of the 100 ma. Coolidge, will accept 300 ma. for one-half second at less than 60 K.V.P. without any evidence of strain on the tube or impairment of it. The 10 K.W. tube will accept 300 ma. for two-tenths of a second, with the kilovoltage noted above, without any difficulty. However, when the penetration is increased above 60 K.W.P., damage to the tube may result.

These limitations hold true for all cooled tubes, the only difference being the greater amount of energy accepted by the line focus tubes as compared with the point focus tube with the same effective focal area.

Much has been said about the effect of size of the focal point on the production of clear-cut detail, and it has often been stated that at a distance of six feet a broad focus tube will give as good definition as does a fine focus tube. In checking this statement and even increasing the distance to as much as nine feet, the fallacy of this argument is definitely proven, as a novice would be able to detect which film was taken on the broad focus tube and which on the fine.

Definition is not satisfactory at any distance when a tube with a focal point of more than 12 mm. is used, and if it is possible to obtain a tube which will handle the load for the average chest with a focal point

of 8 mm., this is the tube of preference. Unfortunately, chests which measure more than the average in depth cannot be handled by this tube, as the use of it at more than 80 K.V.P. is hazardous.

A recent article by Kearsey describes a new tube which has an automatically adjustable focal point, varying directly with the milliamperage. It is questionable whether this tube will ever have a practical application, as the focal spot would be too large when a 250 ma. current is used, judging from the illustrations accompanying the article.

Another notable difficulty is that all Universal tubes will not fulfill identical conditions, even though their apparent characteristics, including focal points, are the same. When one purchases a new Coolidge tube, the checking of it is approached with a mixed feeling, in which both hope and fear are represented. If, after testing, it is found not suited to the work for which it was intended, the purchaser has no redress, but has a tube not applicable to the purpose for which it was procured. Generally speaking, it is impossible to obtain tubes which have been tested at higher capacities, even though no guarantee is asked with them.

Specifications are being submitted for the construction of a line focus tube with effective focal point about 7 mm. square, which we hope will assist in solving our difficulty. This tube is to have a solid tungsten anode and will probably not be cooled.

The economics of high speed work should have serious consideration. In the first place, the chief object of a radiological laboratory is to produce and interpret diagnostic roentgen films. The second consideration is the economic one. The laboratory must be made to pay; otherwise it will not continue in existence.

It is quite evident that the energies noted in this article will cause considerably more tube deterioration than will a 30 ma. technic. It is also quite evident that greater distances increase this deterioration by reason of the additional energy necessary for the production of a satisfactory roentgenogram. Distortion enters into the determination of distance and must be given due consideration.

After evaluating these various factors and considering the question from all angles, it would seem that the optimum target-plate distance in chest work is 84 inches. This gives a distortion factor of about 8 per cent in the average chest, but it allows the use of lesser energies than does the examination at 9 feet, where the distortion amounts to 4 per cent. Of course, only that portion of the patient farthest from the film is distorted 8 per cent, the intervening tissues showing much less distortion.

The chest technic in use at the Clinic employs the use of 250 ma. for one-twentieth of a second at a distance of 7 feet. Kilovoltage is varied from 65 K.V.P. to 125 K.V.P., depending on the depth of the chest, all other factors remaining constant. The technician is required to measure the depth of the patient's chest before radiography, and the optimum kilovoltage for that depth is used. This requires a detailed exposure chart, but results justify the effort. When this technic is followed, it is astonishing to note the few re-takes which are necessary.

In gastro-intestinal work, distortion does not play such an important part, and a much shorter target-film distance may be utilized. This, however, is more than compensated for by the depth of the patient at this level and the fact that instead of aërated tissue there are solid structures to penetrate. The focal point need not be so small in this work, as the deviations from normal observed in gastro-intestinal work are more of a gross nature. The opaque medium furnishes a very good contrast, so that the kilovoltage may be considerably increased over that used

in chest work. The exposure, instead of being one-twentieth of a second, is one-tenth.

Examination of the abdominal soft tissues, such as kidney, gall bladder, and spleen, requires the utilization of the Bucky diaphragm. This of necessity increases the exposure time very markedly, but speed is none the less essential, inasmuch as these structures are subject to much the same motion factors as are the structures which have been previously considered. In view of the great total amount of energy required for this exposure, it has not been found practical to reduce the time below three seconds, and accordingly a 10 K.W. Muller tube at 100 ma. for three seconds, again varying kilovoltage with the depth of the patient, will produce the best results. If a finer focal point is deemed advisable, the 6 K.W. tube may be utilized, but the milliamperage necessarily must be cut in half and the time doubled, otherwise the tube may be damaged. The 10 K.W. tube gives detail as fine, if not finer, than is obtained when the 5-30 Coolidge radiator is used.

CONCLUSIONS

Fast radiography is not a passing fancy, nor is it an experimental effort in which a few radicals are interested. It appears that it is an essential procedure for the production of accurate and satisfactory technical work. The laboratory which is not utilizing the many advantages obtained through its use is antiquated and is working a hardship on its roentgenologist, inasmuch as he is called upon to interpret roentgenograms which are not the best.

Roentgenological interpretation under any but optimum conditions, including the best possible films obtainable, is difficult. The roentgenologist should have every aid obtainable to assist him in interpretation, and the greatest single aid in interpretation of those structures lying inside the bony thorax and the abdominal cavity is the use of films taken in the shortest time possible through the use of a milliamperage varying from one hundred upwards, combined with high kilovoltage.

THE EFFECT OF VARYING VOLUMES OF AIR ON THE DISTRIBUTION OF ROENTGEN ENERGY IN A NON-HOMOGENEOUS MEDIUM

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Section on Therapeutic Radiology, The Mayo Clinic, ROCHESTER, MINNESOTA

THE distribution of roentgen energy in a homogeneous medium such as paraffin or water under conditions comparable to those under which various parts of the human body may be irradiated therapeutically is fairly well known. Conclusive information is lacking, however, concerning the distribution of roentgen intensity in a medium which is not homogeneous, and in which varying proportions of air and the absorbing medium are mixed. The advantage of having information on the influence of known amounts of air on distribution of energy in an absorbing body comparable with, although not identical with, the human body is obvious, especially when treatment of such regions as the thorax and abdomen is considered. An attempt was made to obtain information on this point by studying the "dose" of roentgen rays at a depth of 10 cm. in a block of paraffin in which known volumes of air were substituted for paraffin at different levels. Similar researches have been made by Wintz and Rump, by Glasser, and by Weatherwax and Robb, but under different experimental conditions, and the experiments were designed to determine the effect of different volumes of air on the roentgen intensity at different depths. Their conclusions, therefore, are not directly applicable to the problems set forth here, in which the depth remained unchanged.

METHOD

A number of plates of paraffin, each of which measured 20 by 20 by 0.5 cm., were piled so as to form a solid block. Plates with visible bubbles of air were discarded. It is probable that many of the plates contained minute volumes of air, but since the individual volume was small and the number of plates large, the chance of the results being vitiated by the presence of any considerable quantity of air was practically excluded.

As a measuring device we have used one or the other of two "thimble type" ionometers designed to measure therapeutic quantities of roentgen rays. Both instruments were protected with lead to exclude all radiation not incident to the chamber. These ionometers were known to have a different hardness error and the measurements obtained by the two differed slightly. The curves derived from such measurements did not have the same value, but had the same general shape. The readings given in this paper are those obtained by the more accurate of the two instruments.

The ionization chamber was placed at the surface, half submerged in a depression in the paraffin which it fitted exactly, and also at a depth of 10 centimeters. When air was to be substituted for paraffin a sufficient number of plates was removed from the block to leave an open space of known dimensions, the initial dimensions of the block remaining the same.

The conditions under which the paraffin was irradiated were as follows: transformer outfit with mechanical rectifier, 195 kilovolts peak, measured by spheres 125 millimeters in diameter; 5 milliamperes of current measured by two ammeters in the high tension circuit; Coolidge air-cooled tube in a tank tube-holding device; rays filtered through 0.75 millimeter of copper and 2 mil-

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limeters of aluminum; 50 centimeters focal distance; surface field 10 by 10 centimeters cut in a lead plate 3 millimeters thick, and ward the surface in steps of 1 centimeter each until the upper plane of the layer of air was 2.5 or 3 centimeters under the sur-

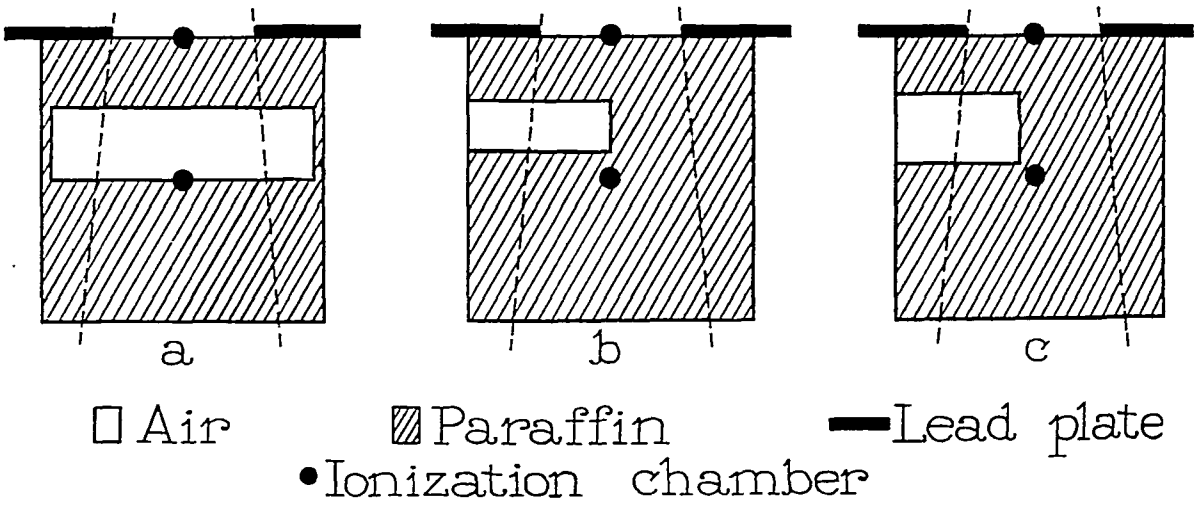


Fig. 1.

the pile of paraffin 20 by 20 by 20 centimeters. The coefficient of absorption of the paraffin was found to be 0.163, and the effective wave length of the roentgen rays. measured by the method of Duane, was 0.15 Ångström unit. The intensity at a depth of 10 centimeters in the solid block of paraffin was 38.3 per cent.

Both the surface and depth intensities were measured under the following different conditions:

1. With air spaces 2, 3.5, and 5 centimeters thick, respectively, extending across the block as shown in Figure 1 (*a*).

2. With layers of air 3.5 and 5 centimeters thick, respectively, situated at the side of the block, as shown in Figure 1 (*b* and *c*). Two different positions were chosen for the layer of air at the side of the block. In one, the plane of division between air and paraffin fell on the axis of the ionization chamber (Fig. 1 (*b*)); in the other, the the plane of division fell on the side of the chamber (Fig. 1 (*c*)).

The different layers of air were moved upward from the level of the axis of the chamber, at a depth of 10 centimeters to-face of the paraffin block, and comparative measurements of ionization were made at each step.

RESULTS

When a layer of air was placed across the block of paraffin, as in Figure 1, the depth intensity of roentgen rays varied as shown in Tables I, II, and III and also in Figures 2, 3, and 4.

TABLE I

EFFECTS OF A LAYER OF AIR 2 CM. THICK EXTENDING ACROSS THE BLOCK OF PARAFFIN

Distance of layer of air from ionization chamber (cm.)	Distance of layer of air from upper surface (cm.)	Air in block (per cent)	Intensity compared with that seen when a solid block was used (per cent)		Intensity at depth of 10 cm. compared with intensity at surface of same block (per cent)
			At upper surface	At depth of 10 cm.	
	8	22.91	100.0	96.13	36.82
1	7	22.16	100.0	104.4	40.0
2	6	21.44	99.5	107.6	41.42
3	5	20.69	99.37	110.6	42.59
4	4	19.95	97.3	112.8	44.36
5	3	19.21	95.36	113.8	45.60

With a small amount of air, as when a layer 2 centimeters thick was used, the intensity was actually less than in the solid block when the inferior plane of this layer lay at the level of the axis of the ionization chamber. However, in moving this layer of

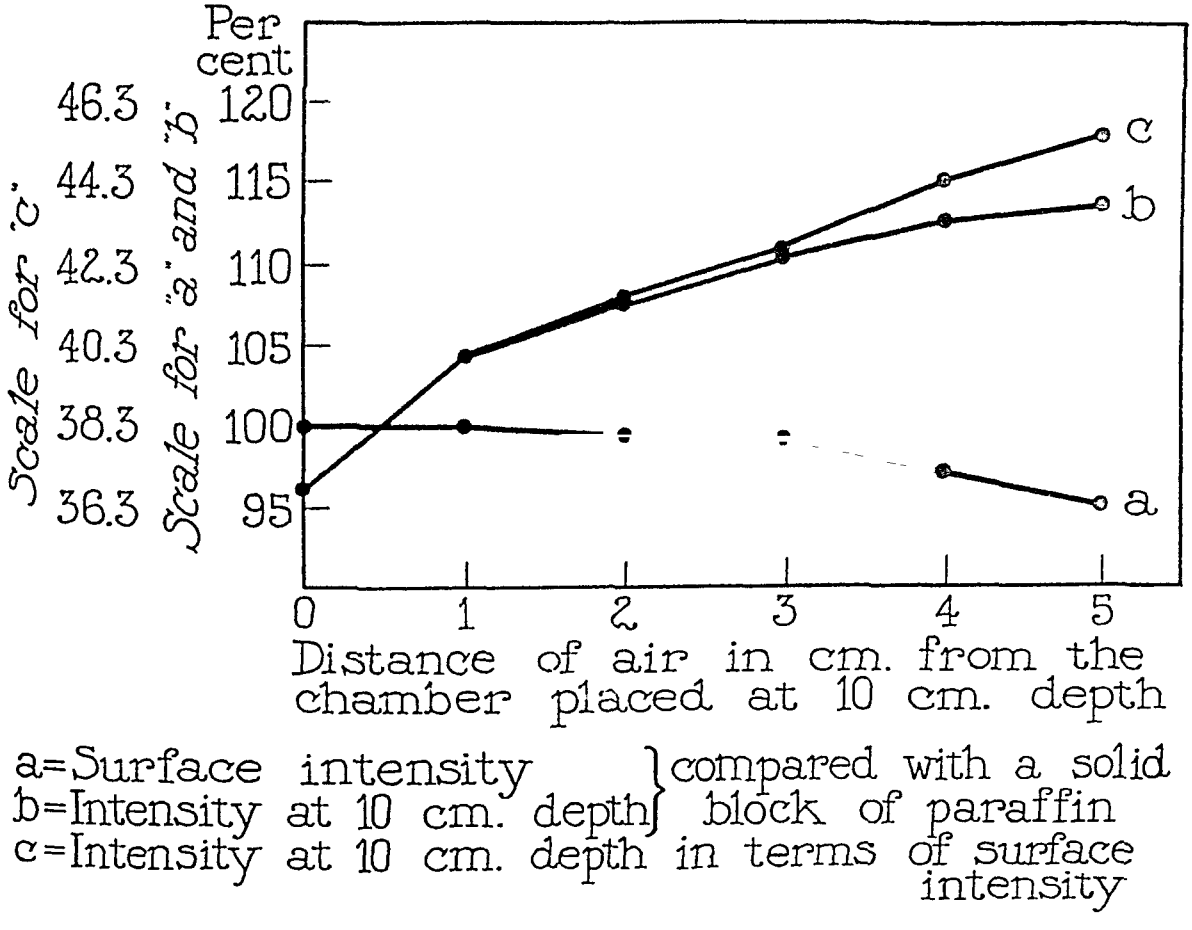


Fig. 2.

TABLE II

EFFECTS OF A LAYER OF AIR 3.5 CM. THICK EXTENDING ACROSS THE BLOCK OF PARAFFIN

Distance of layer of air from ionization chamber (cm.)	Distance of layer of air from upper surface (cm.)	Air in block (per cent)	Intensity compared with that seen when a solid block was used (per cent)		Intensity at depth of 10 cm. compared with intensity at surface of same block (per cent)
			At upper surface	At depth of 10 cm.	
	6.5	39.16	100.0	102.8	39.37
1	5.5	37.84	99.4	112.6	43.37
2	4.5	36.60	98.64	119.7	46.47
3	3.5	35.20	96.67	123.8	48.97
4	2.5	34.05	95.4	127.8	51.22

air toward the surface of the block, the intensity increased markedly.

When the layer of air used was 3.5 or 5 centimeters thick (Tables II and III, Figs. 3 and 4), the intensity at a depth of 10 centimeters increased, as compared with the solid block when the inferior plane of the layer of air was in the axis of the chamber. When the air was moved toward the surface, the increase was more marked than in the first instance. As can be seen in Figures 2, 3, and 4, the rate of increase in intensity as the layer of air was moved away from the ionization chamber was rapid at first. It then decreased and was most marked when

the air was farthest from the ionization chamber.

The surface intensity also was influenced by an underlying layer of air, as can be seen in Tables I, II, and III, and Figures 2, 3, and 4. When the layer of air was 5 centimeters or more below the surface, and extended across the width of the block of paraffin, the surface intensity was not affected.

Different results were obtained when the air was placed at the side of the block, as in Figures 2 and 3. The depth intensity when the plane of division between air and paraffin was the axis of the chamber is shown in Tables IV and V. When the division between air and paraffin was in the plane of the side of the chamber the intensity was always less than in the solid block.

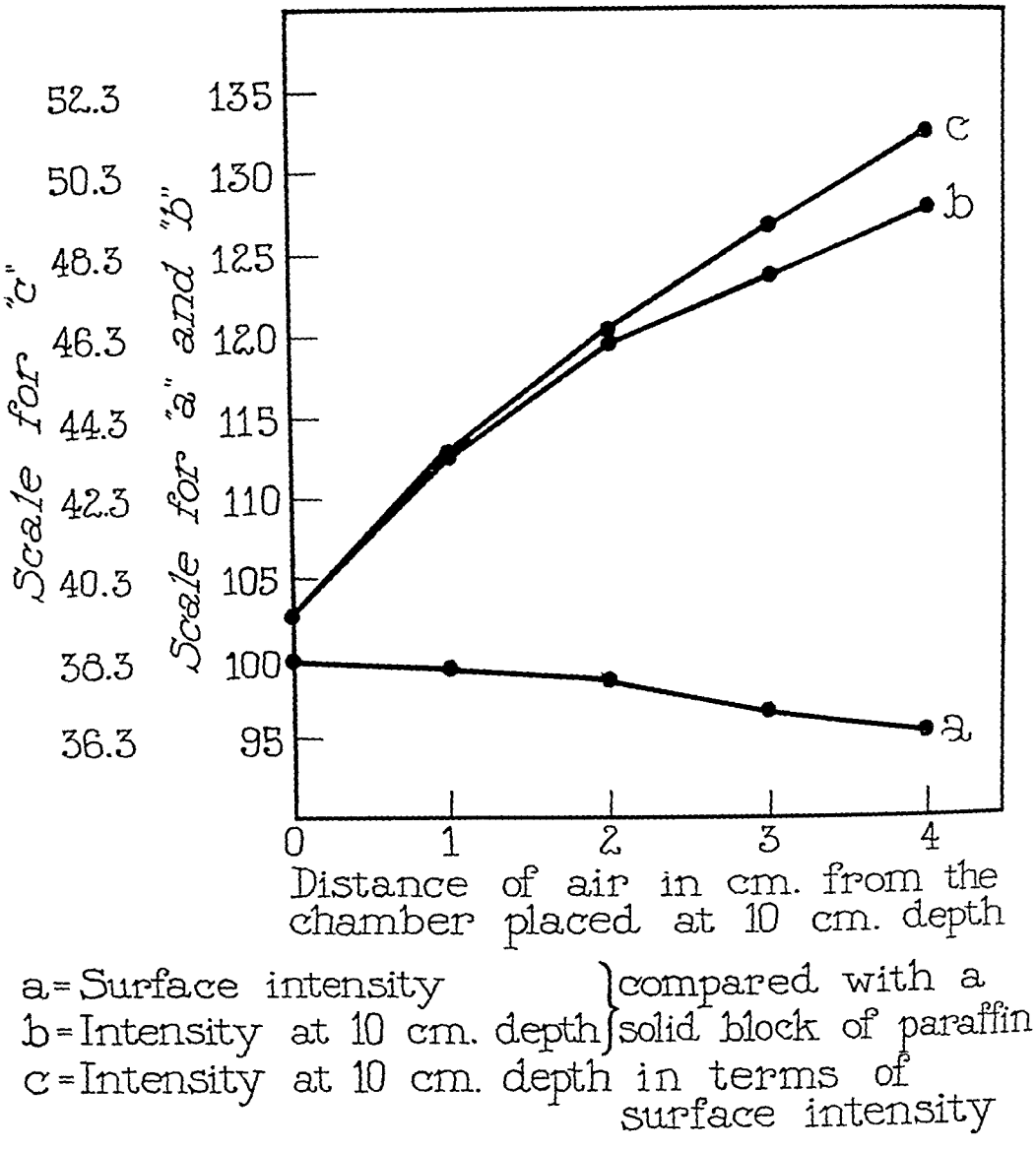


Fig. 3.

COMMENT

These experiments show that the degree to which the intensity at a depth of 10 centimeters is affected by partial substitution of air for paraffin depends on a balancing ef-

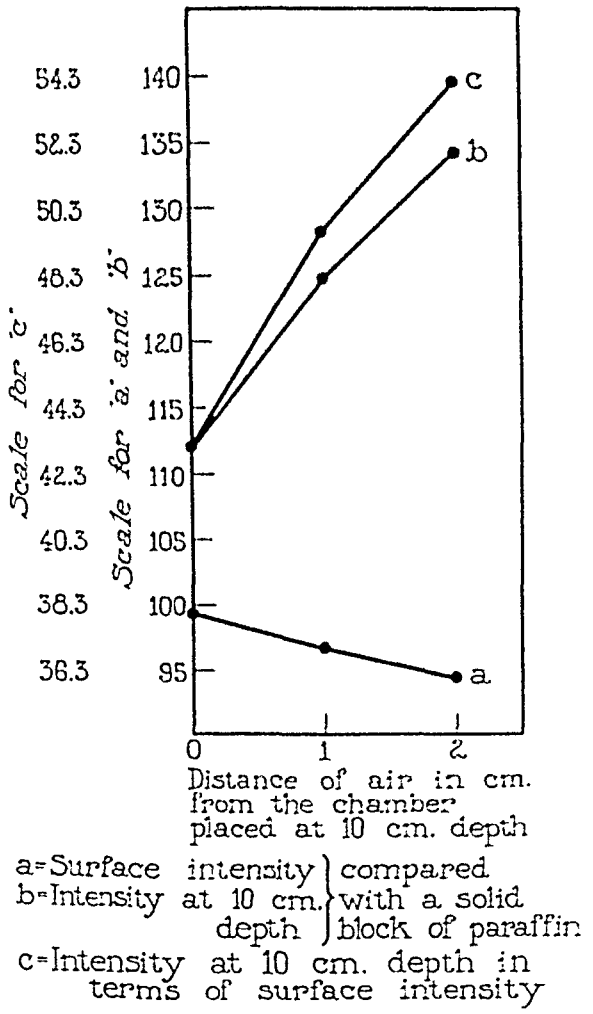


Fig. 4.

fect between the diminished absorption by the air, which tends to increase the intensity, and the decrease in scattering, which tends to decrease the intensity at the same level. By shifting the air from the level of the ionization chamber toward the surface without changing the proportion of air and paraffin, the main variable is the scattering.

The intensity measured at the surface also was influenced by an underlying layer of air, but no such influence could be detected when the air was at a depth greater than 5 centimeters below the surface. Back-scattered rays, therefore, did not appear to travel in a direction contrary to that of the primary beam through more than 5 centimeters of paraffin. But when the layer of air was 2.5 centimeters beneath the surface, the inten-

TABLE III

EFFECTS OF A LAYER OF AIR 5 CM. THICK EXTENDING ACROSS THE BLOCK OF PARAFFIN

Distance of layer of air from ionization chamber (cm.)	Distance of layer of air from upper surface (cm.)	Air in block (per cent)	Intensity compared with that seen when a solid block was used (per cent)		Intensity at depth of 10 cm. compared with intensity at surface of same block (per cent)
			At upper surface	At depth of 10 cm.	
	5	54.58	99.31	111.8	43.11
1	4	52.60	96.65	124.6	49.32
2	3	50.87	94.5	134.3	54.16

TABLE IV

EFFECTS OF A LAYER OF AIR 3.5 CM. THICK PLACED AT THE SIDE OF THE CHAMBER

Distance of air from ionization chamber (cm.)	Ionization chamber half covered by paraffin		Ionization chamber fully covered by paraffin	
	Air in block (per cent)	Intensity at depth of 10 cm. compared with intensity at surface of same block (per cent)	Air in block (per cent)	Intensity at depth of 10 cm. compared with intensity at surface of same block (per cent)
	19.58	40.04	16.3	36.03
1	18.92	40.88	15.63	37.03
2	18.30	46.39	15.05	37.47
3	17.60	45.23	14.41	38.68

TABLE V

EFFECT OF A LAYER OF AIR 5 CM. THICK PLACED AT THE SIDE OF THE CHAMBER

Distance of air from ionization chamber (cm.)	Ionization chamber half covered by paraffin		Ionization chamber fully covered by paraffin	
	Air in block (per cent)	Intensity at depth of 10 cm. compared with intensity at surface of same block (per cent)	Air in block (per cent)	Intensity at depth of 10 cm. compared with intensity at surface of same block (per cent)
	27.29	37.37	22.55	35.37
1	26.3	39.07	21.64	36.35
2	25.43	46.65	20.45	35.15

sity at the surface was only 4.6 per cent less than in the solid block, which shows that the greatest amount of scattering came from the medium immediately surrounding the chamber.

CONCLUSIONS

Measurement of the intensity distribution of roentgen rays in the depths, as well as at the surface, of a paraffin block, are altered by various volumes of air and also by the relative position of the air with reference to the paraffin and to the ionization chamber. The greater the volume of air the greater are the changes noted. These are due to a balancing effect between decreased absorption and scattering of the incident rays in comparison with the absorption and scattering in a solid medium.

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REPORT ON THE USE OF RADIUM AND DEEP THERAPY X-RAY FOR THE LAST SEVEN YEARS IN A PRIVATE CLINIC IN MAINE, WITH SPECIAL REFERENCE TO THE PROBLEMS OF THE SMALL COMMUNITY[1]

By BARBARA HUNT, M.D., BANGOR, MAINE

MY defense for occupying your time and attention with this small group of cases lies in the necessity for investigation and evaluation of the small clinics. Until cancer services become better organized and hospitals become more commonly equipped with radium and deep therapy X-ray machines, there is a field for these institutions with their proximity and close touch with the public. In this way, perhaps, they aid in the earlier recognition and treatment of malignancies, from which quarter there is hope of bettering our results.

Our clinic is equipped with a supply of radium element, amounting to 210 milligrams, contained in six needles of steel alloy, 12½ milligrams each; three capsules of 5/10 millimeter silver, two containing 50 milligrams of radium, the other 25. A deep X-ray therapy machine of 200,000-volt capacity was added in 1923, and changed to a constant potential type in 1928. The erythema time of the latter is about 80 minutes at 180,000 volts, copper 5/10 millimeter, aluminum 1 millimeter, distance 50 centimeters, with a wave length of about 0.17 to 0.21 measured by a Duane ionization chamber. There is also an electrocoagulation machine. A competent pathologist and surgeons are available.

CANCER OF THE SKIN

This is the largest group of cases, numbering 279, with deaths from cancer 24, and cases known free from disease 197. These cancers, while among the easiest to cure when treated within a reasonable time from onset, constitute a large item in the morbidity and, of course, have a certain mortality figure. They seem to be more common on the upper portions of the face, a part of the skin subjected to wind and sun and, frequently, heavily tanned. In women, they are apt to come where frames of glasses press. They occur on the tops of ears after frost bites. In some persons, new ones keep appearing on widely separated parts of the face, although a single occurrence is most usual. Those with brown or black pigment are among the most highly resistant and vicious—the local lesion is difficult to stop, and metastasis is common and fatal. For this reason, brown or black moles should always be removed before cancerous change has taken place. This clinic has found radiation safe and reliable for this purpose.

The ordinary rodent ulcer is treated by surface applications of a mixture of gamma and beta rays of radium, about 300 milligram-hours, all given at one sitting, so that individuals can come from quite a distance, receive treatment, and go home the same day. In cases which do not present the common appearance of the basal-celled growth, it is safer to cover the immediate glandular areas with packs. Needles are inserted in bulky growths, in addition to the surface radiation, which should not be omitted. Advanced cases still appear which have been treated with cancer pastes and, sometimes, inadequate doses of X-ray. Such cases seem to me to do better under a combination

[1]Read before the Radiological Society of North America at the Fifteenth Annual Meeting, at Toronto, Ont., Canada, Dec. 2–6, 1929.

of deep therapy X-ray and distance radium radiation.

CANCER OF THE LIP

This group numbers 145 cases, with 21 deaths and 99 cases known to be free from disease. The diagnoses of both these and skin cancers were clinical, based on induration of the base and edges. Wassermann tests have been routine, but a positive Wassermann was not allowed to delay radiation when clinical signs of cancer were present. Among general practitioners there is a tendency to delay radiation in such cases until anti-syphilitic treatment has been given a long trial. This practice leads to a fatal issue.

The common provoking agent is tobacco, and if the lip does not heal promptly, inquiry will almost always reveal re-indulgence in some form. Of course, there are a few cancers occurring in individuals who deny its use: they are apt to have foul teeth or to have suffered an injury to the lip. I find that the general profession is loath to interdict the use of tobacco and I also have all sympathy for these patients, many of whom are aged and have few solaces. However, inspection of the mouths of most tobacco-users shows a chronic inflamed condition which supplies the catalytic agent in those with a cancer strain. Syphilis has not been a prominent factor in my cases.

The treatment was the same as given above—a mixture of gamma and beta radiation at short distance, giving from 300 to 400 milligram-hours on the lip. Sometimes needles were embedded in a bulky growth extending into the mucous membrane of the mouth, and skin erythema doses of deep therapy X-ray or radium pack over the sub-maxillary and sub-mental areas. Palpable glands which might be cervical metastases were treated with erythema doses of both radium and deep therapy X-ray over the same areas. In some cases a needle has been embedded in the gland for from six to eight hours. There has been no serious trouble with metastatic glands since this method of treatment was started. The results have been very satisfactory, both in healing the lesion on the lip and preventing metastasis. The deaths in this series all occurred in patients treated prior to 1926, and among enfeebled individuals with extensive lesions, and with metastasis already established at the time of treatment. There have been no deaths among those treated since 1926. There can be no doubt but that radiation is a highly satisfactory and reliable method of treating cancer of the lip. It, also, seems to be popular with the public.

CANCER OF THE MOUTH

There are 35 patients in this group, of whom 16 are dead and 13 are known to be free from disease. The prognosis of these lesions varies greatly with the character of the growth. Epulis, sarcoma, and some carcinomas yield readily to radiation. The most difficult type is the indurating squamous-celled epithelial ulcer which occurs in the cheek or on the lower alveolar process. This lesion in the mouth is difficult to heal and metastasis is extremely likely. Tobacco is the common cause and leukoplakia and syphilis are often associated with it. Saturation doses of deep therapy X-ray and distance radiation with radium inside the mouth give marked regression and, I think, offer the line of attack, but I have had no ultimate cures in any cases in which the pathological diagnosis showed epithelial pearls.

CANCER OF THE UTERINE CERVIX

The number of cases in this group is 104, the known deaths being 70 and the known cases free from disease 26. There are 13 cases free from disease for five years and 7 cases free from disease for three years. In this group some cases were very advanced,

others had been treated first elsewhere, and some had been curetted a week or two before treatment, which procedure seems to me to make the prognosis more grave. There were but three cases which might be termed operable, all the others having more or less fixation of the uterus. Generally speaking, the proliferating cases, although looking advanced, require less radiation and do better than the eroding and indurating. I do not feel that pathologic section is very valuable as a guide to treatment, although it adds to our knowledge of the disease and aids in the prognosis. The embryonic cell types, although radiosensitive, spread so rapidly that the total dose of radiation is the same as in the other types. It is possible to diagnose the different types of cells by clinical methods, and important not to cause loss of blood nor disturb the cellular structures. Radiation in itself cleans up sepsis and relieves toxemia.

These cases were treated with applications of radium in the uterine canal and packs in the vagina—sometimes needles were placed in bulky growths. A wax catheter covered with rubber, holding either the silver tubes or steel needles, was placed in the canal. The packs were made up for each patient from 1 millimeter of lead, 1/10 millimeter of lead foil, a layer each of paper, cotton batting, and rubber dam. These small flat packs can be fitted to the individual vagina and are placed against the bases of the broad ligaments. The treatments are given three times, a week or ten days apart, the patients going home in the meantime. Patients not infrequently enter the hospital the night before treatment and return home on the day the radium is removed. Effort is made to apply radiation the whole length of the uterine canal, and an average total of from 8,000 to 9,000 milligram-hours is given in the course of three weeks. There is no shock and little nausea; rectal and bladder disturbances are slight, pyometra has not occurred, and the cancerous ulceration disappears and the upper vagina heals over smoothly. Most of the deaths have been caused by broad ligament and abdominal metastases. I do not use deep therapy radiation as a routine, but only when a metastasis is located.

CANCER OF THE BREAST

The number of these patients is 58, of whom 41 are now dead from the disease and 8 are known to be free. A separation may be made of the cases treated for post-operative recurrence and those treated by radiation alone: of the former, all except two have died from metastasis to liver or lung, with the external lesion under control; in the latter group there were many extremely advanced, desperate cases for whom the most to be hoped was palliation. However, there were six potentially operable individuals who chose radiation in preference to operation: of these, five are living and in good health; the other one died within two weeks after receiving a second course of deep X-ray therapy. Perhaps her death was caused by the treatment. This point is significant; none of the five receiving radiation had metastasis, which is a common cause of death after surgical excision. Two of these cases were treated with radium embedded in the tumor and four with deep therapy X-radiation. I now use the deep X-ray therapy exclusively in the treatment of cancer of the breast because of difficulty in avoiding painful skin reaction from radium. It is well known among radiologists that cancerous tumors of the breast are often very radiosensitive. For this reason I believe in pre-operative radiation.

SURVEY OF X-RAY THERAPY

Radiation treatment of cancers of the uterine fundus, vulva and vagina, rectum and prostate is not very satisfactory. It is

true that no method of treatment of these lesions is satisfactory; however, radiation has produced some arrests.

Of four cases of cancer of the foreskin, three lesions have healed, while one patient died shortly after a surgical excision.

Radiation treatment for uterine fibroids, with menorrhagia, has been very satisfactory, both to patients and the doctor. Flowing stops immediately and the tumors disappear gradually.

The treatment of hyperthyroidism by radiation deserves consideration. The basal metabolism can be returned to normal and the symptoms relieved in many cases, so that these individuals are able to continue at work. A second or third treatment—and patience—are sometimes necessary. One of my cases has suffered from a mild myxedema since radiation, which is, however, controlled by thyroid medication. She is not dissatisfied and considers her condition much improved.

Lupus vulgaris has yielded to radium radiation in slightly less dosage than for cancer.

As an aid in handling the cancer situation in the State of Maine, the State Medical Association, co-operating with the Maine Public Health Association, has started public diagnostic clinics in the smaller cities and villages wherever there is a demand from the local physician. The family physician is urged to attend these clinics with his patient, and usually does so. Afterward there is held a dinner or smoker, providing opportunity for discussion with the local fraternity of diagnosis and treatment. The visiting examiners attending these clinics are surgeons and radiologists, thus providing the co-operation which is an essential factor in dealing successfully with the problem of cancer.

SUMMARY

Report of end-results in cancers of skin, lip, mouth, uterine cervix, and breast.

Discussion of causes, and methods of treatment.

DISCUSSION

DR. HENRY SCHMITZ (Chicago): May I make a few remarks upon the diagnosis of cancer of the cervix? If we wish to get such cases early, a resort to microscopic evidence to clinch the diagnosis must be had. If suspicious looking cervices are found, then in the interests of the patient we should remove tissues for biopsy. Also the microscopic corroboration of a clinical diagnosis is essential, as a case might slip in with some destructive process of the cervix that was not carcinomatous and thus make statistical deductions unreliable.

Concerning the methods of treatment: We have an American method, which is an interval method, with brass or gold filtration. Then we have the Swedish method, which is also an interval method but uses heavy filtration. And finally the French method of Regaud should be mentioned, which is essentially that of platinum filtration and a continuous insertion of small amounts of radium salts over long periods of time.

It is claimed that the Stockholm and Regaud technics cause less local destruction and the total dosage may be increased to 6,000 and 8,000 milligram element hours. We have observed instances of carcinoma of the cervix in which the light brass-filtered radiation dose did not cause an arrest of growth, but the treatment with lead-filtered radium caused an immediate improvement. It seems to me that any further improvement in radium technic will come with a more general use of heavier filtration.

DR. JOSEPH FRIEDMANN (New York): Dr. Hunt has covered the field fully—and it is an extensive one—so that it is hard for me to take up the entire subject. I will speak briefly on one or two topics on which I have had experience especially, one being

malignancy involving the floor of the mouth. I would prefer that no biopsy be done, because one has a cleaner wound to handle; but most physicians with whom I deal insist upon a biopsy.

In using a plaque in the floor of the mouth, I have found that the results are always disastrous, never a permanent cure. We cocainize the area and insert needles of 10 milligrams each, the number of them used depending upon the size of the area involved. We place these needles about one centimeter from one another, and, if possible, parallel. Roentgenograms are then taken stereoscopically to determine if the needles have been properly placed. If not, they are taken out and re-inserted. The needles are left in from twelve to sixteen hours, and then are removed. We wait at least three weeks and then give deep roentgen therapy—a full erythema dose—to be completed within from five to seven days, depending upon the general condition of the patient; that is, if he is very robust, we can shorten the time of treatment as above; if his general health is not so good, we give smaller doses and complete the treatment in about two weeks. Then we wait from seven to ten days and follow up with a saturation dose, as recommended by Dr. Pfahler. As a rule, these cases clear up very nicely.

In reference to malignancy of the cervical canal and of the uterine cavity, after uterine radiation has been given, we give from 4,000 to 6,000 milligram-hours in three or four treatments, then wait about two weeks and give X-radiation, using 200,000 volts, until a full dose has been given. We have the patient return to the attending physician in from three to six months for observation. If there are then any signs of recurrence, we continue the treatment.

DR. HUNT (closing): I would like to remark on the principle of invariably making biopsies in cancer. In advanced cancer, especially in the hemorrhagic types, it often starts up more heavy hemorrhage. I do not think it is necessary in the moderate or advanced types. The only types in which I think it is of advantage are the early ones, for purposes of diagnosis.

As to the routine deep therapy treatment in uterine cancer, we know that deep therapy applied to the abdomen is very poorly withstood by anemic individuals. I myself have not seen direct evidence of its value. I think it is difficult to locate the malignancy in the abdomen.

Speaking of cancer of the breast, I use deep therapy almost entirely. Radium is so liable to hurt the skin.

CASE REPORTS AND NEW DEVICES

AN ATTACHMENT FOR THE SWEET EYE LOCALIZER

By HAROLD B. THOMPSON, M.D.
SEATTLE, WASHINGTON

In the June, 1930, issue of RADIOLOGY, Harold G. F. Edwards, M.D., of Shreveport, Louisiana, described a very ingenious attachment of a mechanical stage to the old-style Sweet eye localizer, constituting a great improvement in this instrument. I think some one may be interested also in my device, which has been of great aid to me in more accurate eye localization.

The main difficulty in getting exact results with the Sweet localizer lies in the inability of the operator to line up the rod, carrying the ball, with the exact horizontal axis of the eyeball. In regular use, the patient is supposed to fix his vision on a distant object with the upper or uninjured eye in order to stabilize the horizontal axis of the injured eye. With the patient's eyes fixed, the operator is then supposed to sight through the two V-slots in order to place the rod of the ball in line with the horizontal axis of the eye.

It must be apparent to any one who has

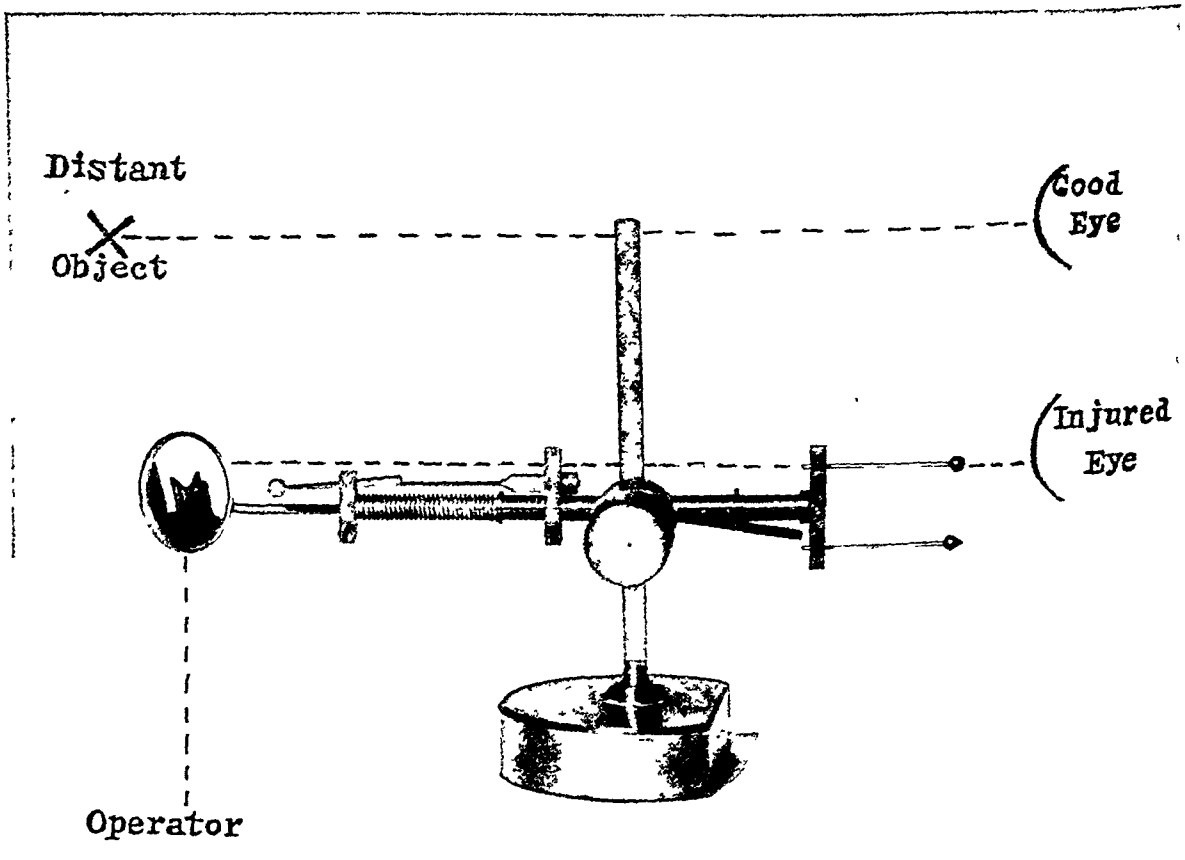


Fig. 1. An ordinary throat mirror attached to the upright standard at approximately a 45-degree angle to the line of the sights

used the instrument that, in looking through the sights, the operator's head is in the direct line of vision of the patient. The patient then cannot fix his vision on the distant object and the horizontal axis of the eye cannot be kept stationary. The accuracy of the whole procedure is based on this fundamental requirement, and if the rod of the ball is not in line with the horizontal axis of the eye, the whole calculation will be incorrect.

To obviate this, the author has attached an ordinary throat mirror to the upright standard at approximately a 45-degree angle to the line of the sights (Fig. 1). This allows the patient a clear field of vision, enabling him to fix his good eye on a distant object, thereby stabilizing the horizontal axis of the injured eye. At the same time the operator, through the mirror, can exactly adjust the rod of the ball to the exact center of the pupil.

A METHOD FOR CONTROLLING THE PETROUS TEMPORAL SHADOW

By W. A. RUSH, M.D., Roentgenologist, Hepperlen Clinic and Lutheran Hospital,
BEATRICE, NEBRASKA

In spite of well-calculated angles, in making X-ray films of the accessory nasal sinuses we often find that the shadows of the petrous portions of the temporal bones coincide with those of the sinuses, thereby causing difficulty in making a diagnosis.

The explanation which follows describes a maneuver that will throw these undesired shadows entirely out of the way and eliminate uncertainty as to where they will fall.

The petrous portions of the temporal bones are in the same horizontal axis of the skull as the external auditory meatus. This fact was determined by submerging skulls in water to the level of the external auditory meatus. Rotation of the skull, maintaining this level, demonstrated that the petrous temporals lie in this axis of rotation.

Since it is difficult, in centering the X-ray beam at the middle of the back of the skull, to ascertain where this beam will strike the

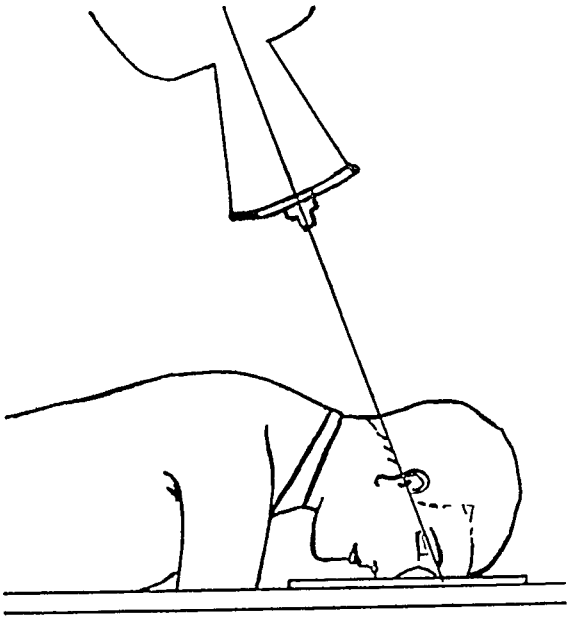


Fig. 1. The central X-ray beam is sent through the external auditory meatus and kept there. The X-ray tube is then angulated so that the beam falls through this point and onto the roentgen film at the place desired for the shadows of the petrous portions of the temporal bones to fall.

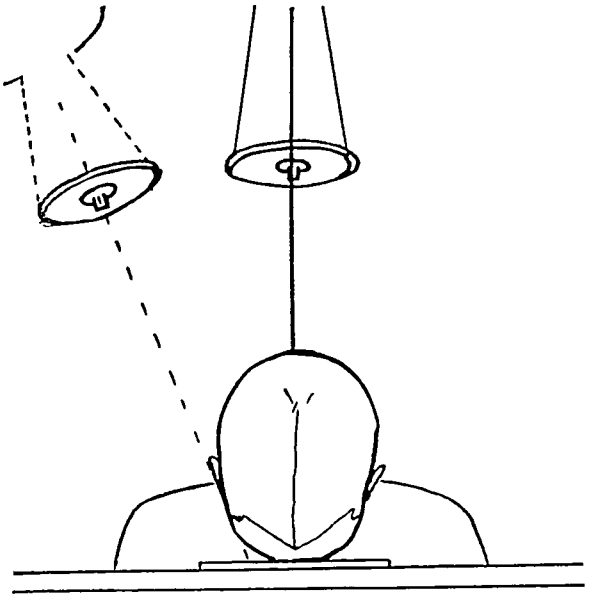


Fig. 2. Front view, showing final position of tube.

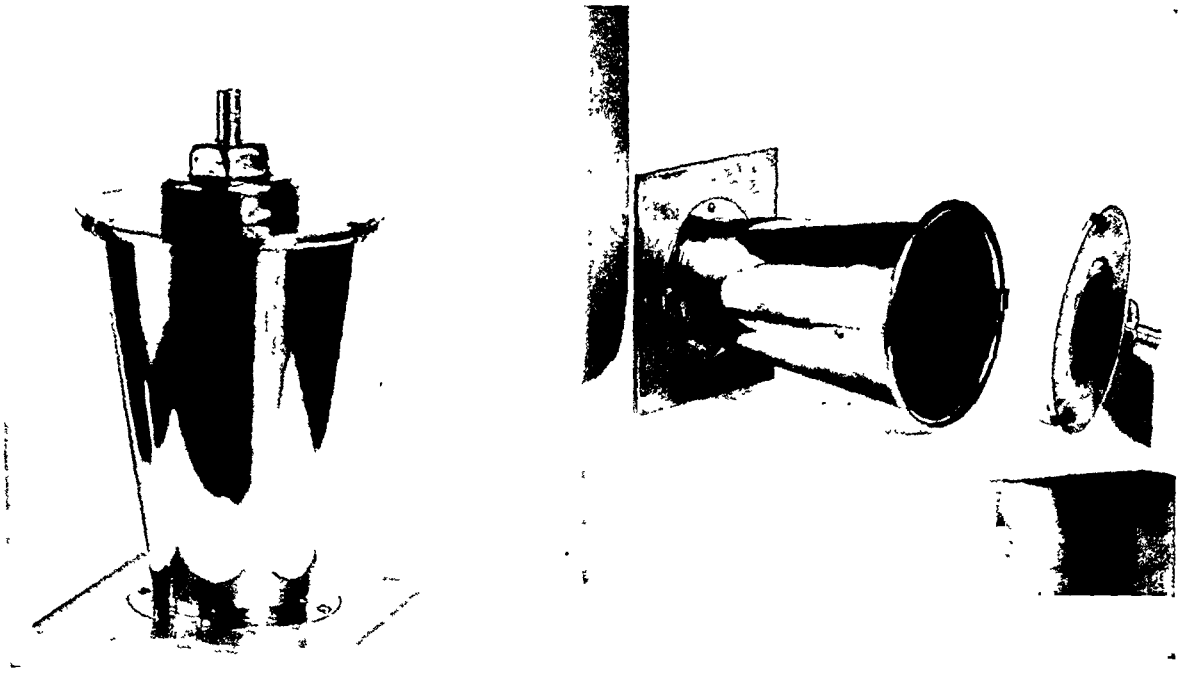


Fig. 3. The device employed for making use of reflected light from the face of the anode to locate the central beam.

X-ray film, we put the above information relative to the positional relationship between the petrous temporals and the external auditory meatus into use. If the central X-ray beam is focussed on the side of the head, it is possible to determine where it will fall on the film. Therefore, we use the external auditory meatus as the visible landmark of the petrous portions of the temporal bones.

The central X-ray beam is sent through the external auditory meatus and kept there. The X-ray tube is then angulated so that the beam falls through this point and onto the roentgen film at the place desired for the shadows of the petrous portions of the temporal bones to fall (Fig. 1).

The tube is kept at this angle and then moved horizontally so that the beam strikes the patient's head in the sagittal center (Fig. 2). The exposure is made, and, when developed, it will be found that the shadows of the petrous portions of the temporal bones fall exactly where desired.

For instance, if the central beam is thrown in line with the external auditory meatus and the external canthus of the eye, the petrous shadows will coincide with the orbital shadows when the film is made and developed.

Figure 3 shows the device employed for making use of reflected light from the face of the anode to locate the central beam.

A TIME SWITCH OF UNUSUAL DESIGN

By ROBERT B. TAFT, M.D., B.S.,
CHARLESTON, SOUTH CAROLINA

About three years ago the author designed and constructed a simple time switch which has answered every need of accuracy and permanency. When set at any desired time, it will continue to give that exposure as many times as the button or foot switch is pressed. When fluoroscopy is used, the timer is disconnected by a small switch, which may be located on any convenient part of the apparatus.

Certainty of Radiological Interpretation

depends upon many factors, but above all upon the contrast medium

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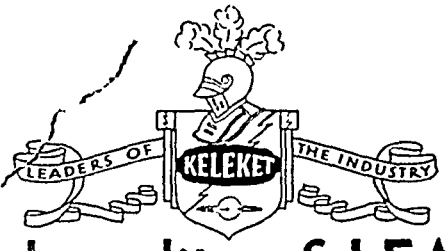


The hard, sharp crystals, which look like broken glass, shown in the first four cuts of the series of micro-photographs can hardly be expected to give satisfactory suspensions and are furthermore very likely to cause irritation to the sensitive linings of the stomach and intestines.

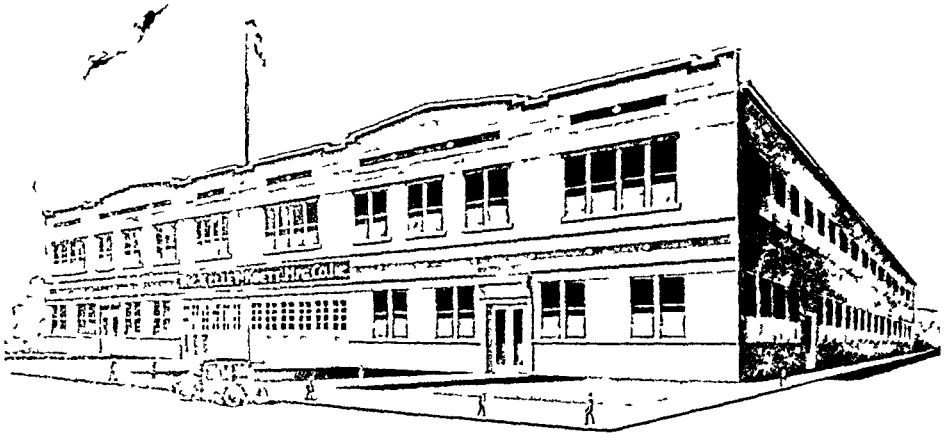
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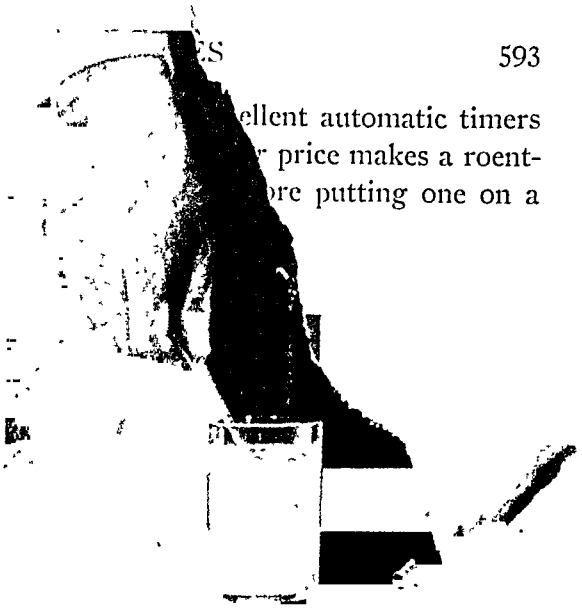
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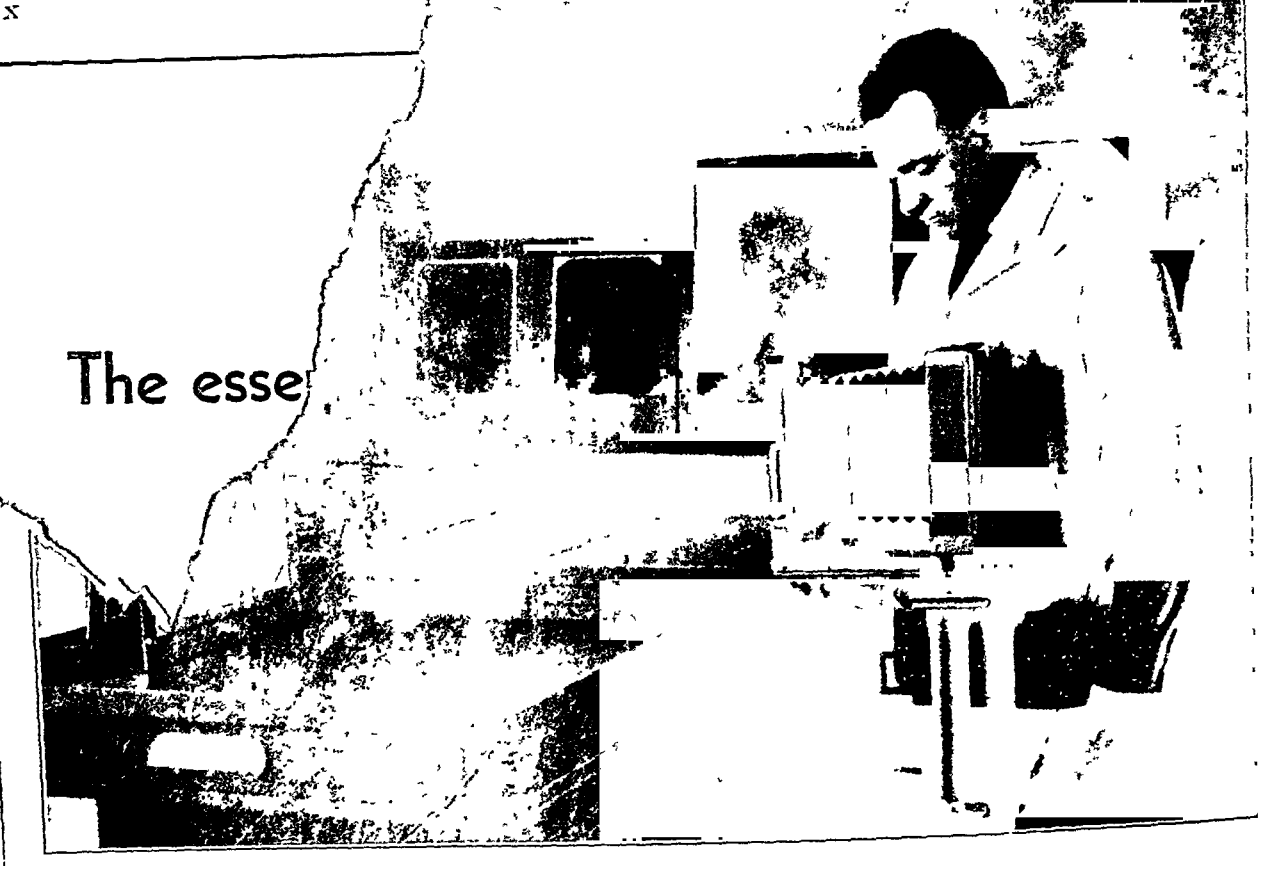
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With the idea of making radiographs at the time of fluoroscopy becoming more general, a simplified time switch of automatic control is a great help, as the necessity of resetting the small hand timer before each exposure is rather a nuisance when multiple exposures are being made. Of course, there are excellent automatic timers on the market but their price makes a roentgenologist hesitate before putting one on a small machine such as is generally employed for fluoroscopy

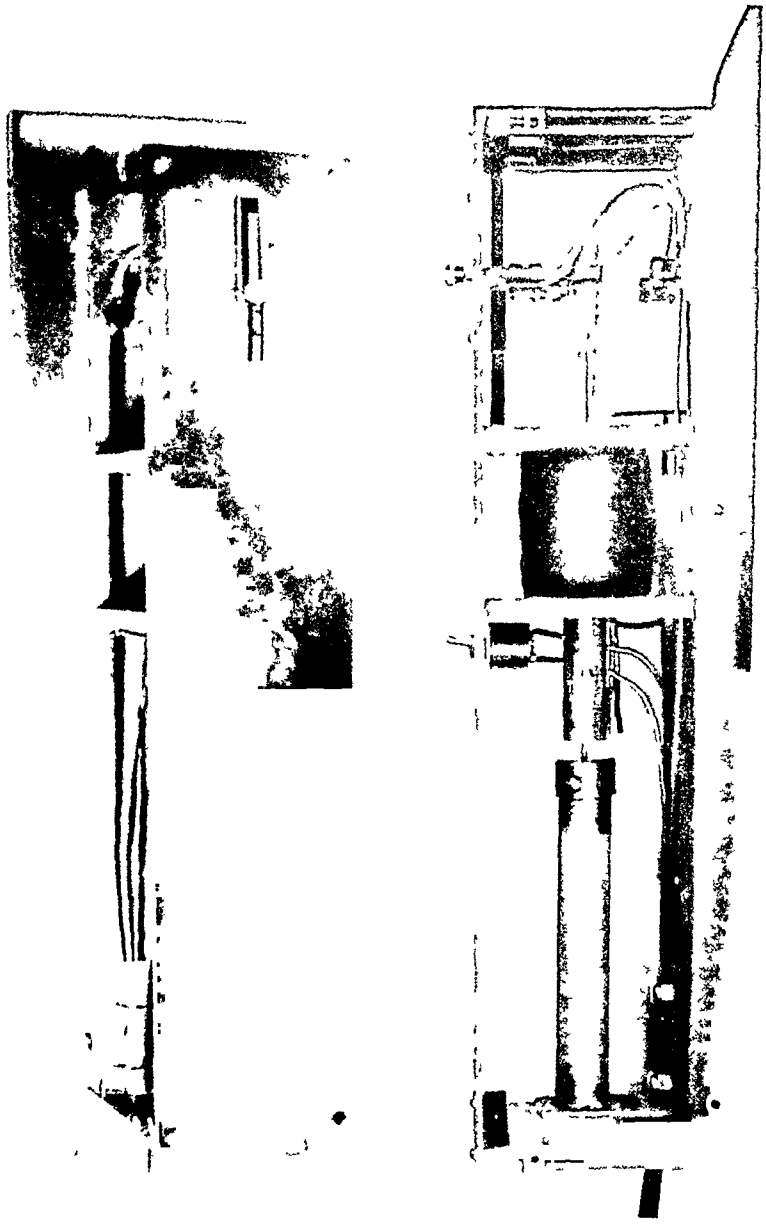


Fig. 1. Front and side views of the author's time switch

The principle involved is that of a solenoid which pulls a core through an oil dash-

pot. The contact system is extremely simple, and so far as the author knows, has not been employed previously, all of the the diagram (Fig. 2), as soon as the button is pressed which energizes the X-ray machine and the time switch solenoid, the core

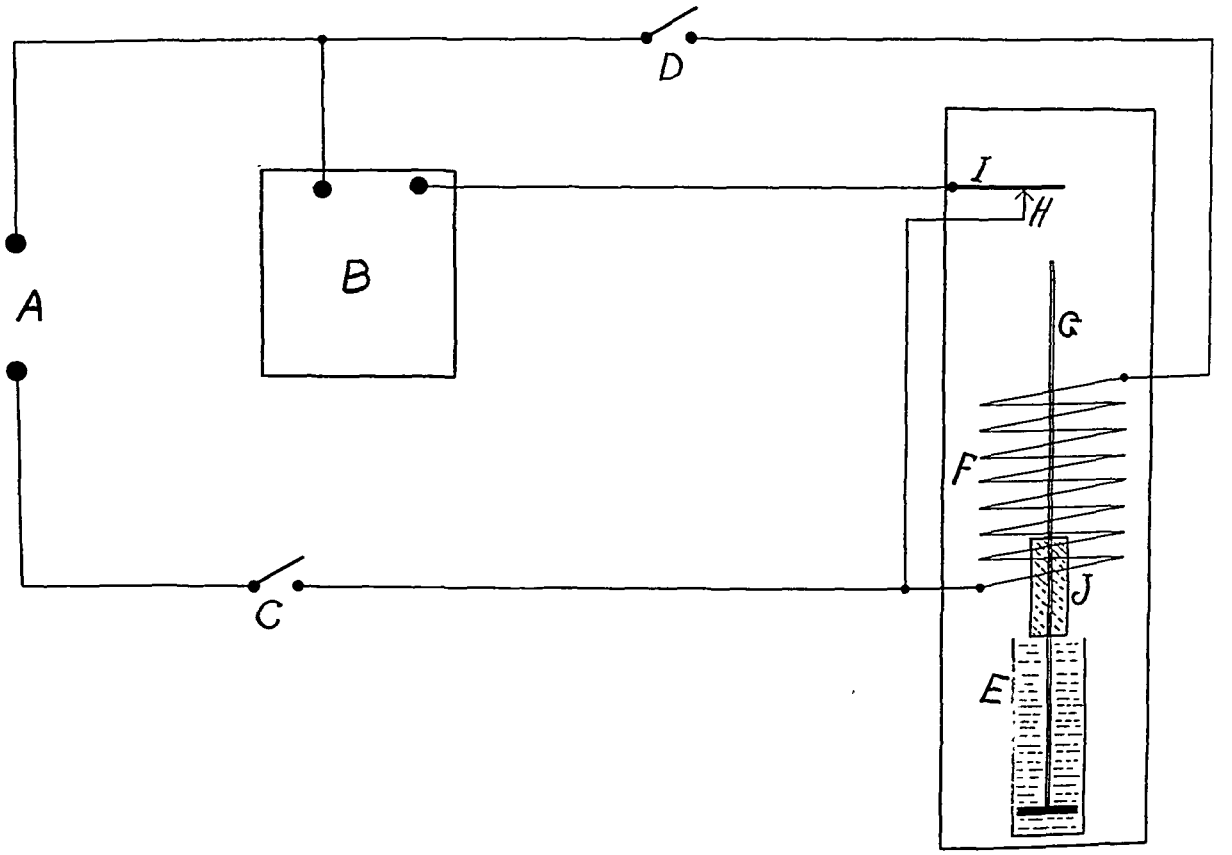


Fig. 2. Diagram of connections for time switch: (A) Connection to main line; (B) magnetic relay on X-ray machine; (C) control switch for X-ray machine; (D) cut-out switch for timer; (E) oil dash-pot with piston; (F) solenoid; (G) brass rod; (H) lower contact point; (I) upper contact point; (J) steel core.

switches on the market using a much more complicated system.

The variable factor in this time switch is the distance which the core moves: the other factors, such as the strength of the magnet and the drag through the oil, remain constant. This feature introduces many elements of simplicity, inasmuch as oil valves are extremely unreliable so far as any accuracy goes. However, the distance of the travel can easily be arranged by simply varying the distance of the contact point mounting from the core. As can be seen by begins to lift upward, carrying with it a piston in the oil dash-pot. When the brass rod touches the upper contact point mechanism this contact is separated from the lower contact which opens the circuit to the X-ray machine, but not to the solenoid. When the operator removes his finger from the control button the core falls back down to its original position. Of course this switch is intended to be used in conjunction with a magnetic relay, such as is found on all modern X-ray machines, but a condenser of two microfarad capacity is shunted across the

contact points, which practically eliminates arcing. The contact points themselves need not be of any high-grade material, as those which are used on the old style Ford ignition coil give excellent service. The solenoid is wound with approximately two pounds of No. 28 B & S gauge copper wire and a center tap should be brought out, because if the instrument is to be used on 220 volts the entire winding is used or if on 110 volts only half of the winding is used. The core itself is a piece of seamless steel tubing three-quarters of an inch in diameter, no special precaution having been taken to eliminate eddy currents. The oil dashpot is a piece of standard three-quarter inch brass pipe and is filled with heavy grade cylinder oil. The piston is a small aluminum button which does not fit tightly into the cylinder. After the switch is once set up the speed of the travel is determined by filing notches in the sides of the piston until the desired speed is obtained.

This particular instrument covers a range of from one-tenth second to four seconds. After the construction is completed the instrument is calibrated by a stop watch for the longer runs and by a spinning top for the shorter runs.

For ordinary purposes this instrument is quite sufficiently accurate although it is not an absolute precision timer, as there is a very slight change in the viscosity of the oil with different temperature changes.

The time which is necessary for the switch to recover itself for the next exposure is about twice the length of the exposure itself. No re-setting is necessary. Should it become necessary to interrupt the exposure the operator has merely to remove his finger from the control button.

The instrument, as herein described, can easily be constructed in the machine shop found in practically every hospital, and the cost of the materials is negligible. It may be placed in any kind of a housing which suits the convenience of the operator, but as the accompanying photograph (Fig. 1) shows, a housing built around the baseboard, consisting of a hard rubber face and glass sides, makes a very pleasing appearance. Figure 2 shows the wiring plan.

This instrument has been so completely satisfactory, having stood hard usage for three years during which time the cover has never been removed for any changes or adjustment, that it is believed this description will prove of value to other roentgenologists.

STATUS THYMICO-LYMPHATICUS: ACUTE EDEMA OF LUNGS

CASE REPORT

By CHARLES W. PERKINS, M.D.
Norwalk, Connecticut

Reading the June, 1930, issue of RADIOLOGY (page 605), I was much interested in H. P. Doub's editorial entitled "The Problem of Enlarged Thymus." Because of the wide diversity of opinion relative to thymic symptoms and studies of that gland, the following report may be of interest. The case came under my observation in November, 1928, while I was Director of the X-ray Department of the United Hospital, Port Chester, New York.

The patient was a supposedly normal child four months of age, without a history of previous illness. While his mother was out of the room, in another part of the house, he was left in his crib alone, any abnormal condition being unsuspected. Upon his mother's return she found him cyanotic and practically moribund. Dr. R. A. Higgons, of Port Chester, was called immediately, but by the time he arrived the child was dead. The supposition is that the child became frightened because of his mother's absence from the room.

The following is the autopsy report made by Dr. Margaret Loder, pathologist of the United Hospital, Port Chester, New York:

"Body is that of a male child, normally developed, particularly large and fat for the age (four months). Testicles descended normally. A few small glands are palpable in the left inguinal region, and one fairly large gland in the right cervical region (anterior). Ear drums appear normal. Frothy material is oozing from both nostrils.

"Chest.—Thymus gland is enormously hypertrophied, measuring 80 x 70 x 30 mm. and weighing 50 grams. Central portions of both lateral lobes show some liquefaction necrosis. Gland covers the aorta, trachea, and bronchi, and comes down well over the pericardium. Both lungs show marked edema throughout. The same material that was seen coming from the nostrils oozes from the larger bronchi. There is no obstruction in the bronchi, trachea, or posterior pharynx. Thoracic nodes are not enlarged. Heart appears normal; chambers are empty.

"Abdomen.—Lymph nodes are enlarged throughout the mesentery, which enlargement appears to be due to a simple hyperplasia, and there is apparently no necrosis of these glands. Other organs appear normal.

"Extremities and genitalia.—Normal.

"Diagnosis. — Status thymico-lymphaticus: acute edema of lungs."

In my paper entitled "Studies of the Thymus, with Roentgen Findings" (*Am. Jour. Roentgenol. and Rad. Ther.,* March, 1929, XXI, 256), I reported the death of a child four years of age who died suddenly in primary anesthesia. The autopsy findings were as follows: status lymphaticus, the thymus gland weighing 35 grams. No previous X-ray examination of this patient's chest had been made.

There is every reason to believe that many cases of sudden death occur in which autopsy findings are not obtained.

EDITORIAL

M. J. Hubeny, M.D. *Editor*
Benjamin H. Orndoff, M.D. . *Associate Editor*

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MEDICAL LEGISLATION

The existing medical laws in this country, with few exceptions, are inadequate to protect our people against the increasing number of quacks and isms. There are about ninety different such cults in this country, a large number of which are openly violating the law, by inflicting their various trades upon an innocent public. It is a well known fact that organized medicine suffers as a result of this unfortunate condition. Whatever action we have taken, or will take against the activities of such persons, is always calculated to protect an unsuspecting public, who depend entirely upon organized medicine for advice in such matters.

We, as physicians, have always been timid in demanding our rights, when adverse medical legislation is proposed. It may be that many of us are fearful that any concerted action manifested by the medical profession may be construed by legislators as coming from a medical trust. Such fear is not well founded. It has been my experience, as a member of medical legislative committees for many years, that legislators will always give a respectful hearing to any medical committee representing organized medicine. As politicians, they appreciate the tremendous influence that organized medicine can bring to bear on any issue. For this reason it becomes the duty of organized medicine in every State, to take advantage of its strength and exert its influence before legislative bodies in defeating any measure calculated to be harmful to the medical profession as well as to the public.

We, as radiologists, are sadly in need of protective legislation at this time. A cursory examination makes it very clear that many States are extremely lax in the protection of the radiologist. One of the most essential legislative acts needed at this time is a revision by amendment of the Medical Practice Act in those States where the radiologist is insufficiently protected. The medical law should be made to read in substance that the practice of radiology is understood to mean the practice of medicine. In this manner the radiologist will be accorded the same protection by law as any of the other specialties of medicine. In this connection, I wish to sound a note of warning in regard to amending any Medical Practice Act. Many of the cults and isms that are unrecognized in many States are awaiting the opportunity of gaining entrance by offering some sort of compromise when such an act is before the legislature for amendment. A compromise is never to be entertained by organized medicine, as ours is a fight for a principle and theirs is one for gain. By concerted action on the part of the radiologists assisted by the rest of the medical profession, such an obstacle is not usually difficult to overcome.

That many of our medical laws are inadequate, particularly in regard to radiology, is proven by a questionnaire sent out by me as President of the Louisiana State Board of Medical Examiners a few years

ago, when it was shown that 52 per cent of State Boards of Medical Examiners stated that no one other than a regularly licensed physician was permitted to practise the science of radiology. Notice particularly, that while 24 State Boards made the preceding statement, in reality 18, or 39 per cent, of them do permit others besides regularly qualified physicians to practise radiology. Would you believe that 15 per cent of State Boards consider the practice of radiology as the practice of medicine only when treatment is administered?

While it is not my purpose to advertise the activities of organized medicine in Louisiana, our records will show that we have not been derelict in our duty in apprehending and convicting law violators. As an example of such activity, I am proud to announce that there is not a single lay person at this time practising roentgenology in our State. Whatever success we have had in this regard is the result of the combination of several important factors, namely:

1. Medical Practice Act.
2. Efficient and courageous secretary.
3. Special attorney working in conjunction with the office of the Attorney-General of the State.
4. Funds for the State Board of Medical Examiners to function efficiently.
5. Co-operation of radiologists with organized medicine.
6. A non-political State Board of Medical Examiners.

MEDICAL PRACTICE ACT

In regard to the Medical Practice Act, it is necessary that teeth be put in the medical law of any State if the State Board is to function efficiently. The Louisiana Medical Law is recognized as among the foremost Medical Practice Acts of the United States, and several parts of it have been adopted by other States. The definition of the practice of medicine, as given in our act, is very detailed and full in its meaning. It is credited with being one of the most complete definitions on record at this time. The law has stood the test of every court in our State and finally the Supreme Court of the United States. The verdict of the Supreme Court is that it is sound in principle and constitutional.

EFFICIENT SECRETARY

The prosecution and conviction of law violators is dependent to a great extent upon the courage and activity of the Secretary of the State Board. We are extremely fortunate in having a Secretary who possesses a phenomenal capacity for pegging away at law violators, and with a bold disregard for danger he has often snatched victory out of the jaws of danger. Our success is largely due to his activity, and I could not praise him enough for the splendid work he has done for organized medicine in Louisiana.

SPECIAL ATTORNEY

Our medical law makes provision for the State Board of Medical Examiners to employ special attorneys in prosecuting law violators. We employ such an attorney by the year and he serves the Board in a manner which yields perfect satisfaction. He is privileged to the advice and assistance of the Attorney-General of the State. Such a special attorney is of incalculable help, as it has been our experience that we could not depend on the district attorneys for much help in the prosecution of law violators.

FUNDS FOR STATE BOARDS

Many years ago our Board was functioning with very little money—just about enough to meet current expenses. We were then unable to employ special attorneys and

special investigators as we do at the present time. For this reason we had incorporated in our law, during the year 1918, an annual renewal fee of $2.00. The annual renewal feature of a Medical Practice Act is one of the best known methods of obtaining sufficient finances in order that a State Board may function properly. It is fair to the physicians, and affords them protection in many ways. Only 10 States, in answer to an inquiry sent out some time ago, have a renewal feature, and 31 have not. From this source alone we have a reserve fund of several thousand dollars at all times.

CO-OPERATION OF RADIOLOGISTS WITH ORGANIZED MEDICINE

Close co-operation between radiologists and organized medicine is imperative, for in no other way can protective legislation be obtained for the radiologists. Two of our radiologists have served as President of the State Medical Society and one of them is at present President of the State Board of Medical Examiners. Several of our radiologists have served as members on the legislative committees of the State and local medical societies. In other words, the radiologists in our State are in every fight, with the other members of organized medicine, against any adverse medical legislation.

A NON-POLITICAL STATE BOARD OF MEDICAL EXAMINERS

A non-political State Board is highly desirable, otherwise the members of this Board may be influenced by politicians against the prosecution of certain law violators. Our Medical Practice Act provides that the State Medical Society shall send to the Governor the names of two physicians, one of whom must by law be accepted by the Governor to fill any vacancy that may exist on the Board. For this reason such an appointment by the Governor is in reality the choice of the State Medical Society and is, therefore, free from any political entanglements.

LEON J. MENVILLE, M.D.,
Chairman of the Legislative Committee, Radiological Society of North America.

THIRD INTERNATIONAL CONGRESS OF RADIOLOGY

Paris, July, 1931

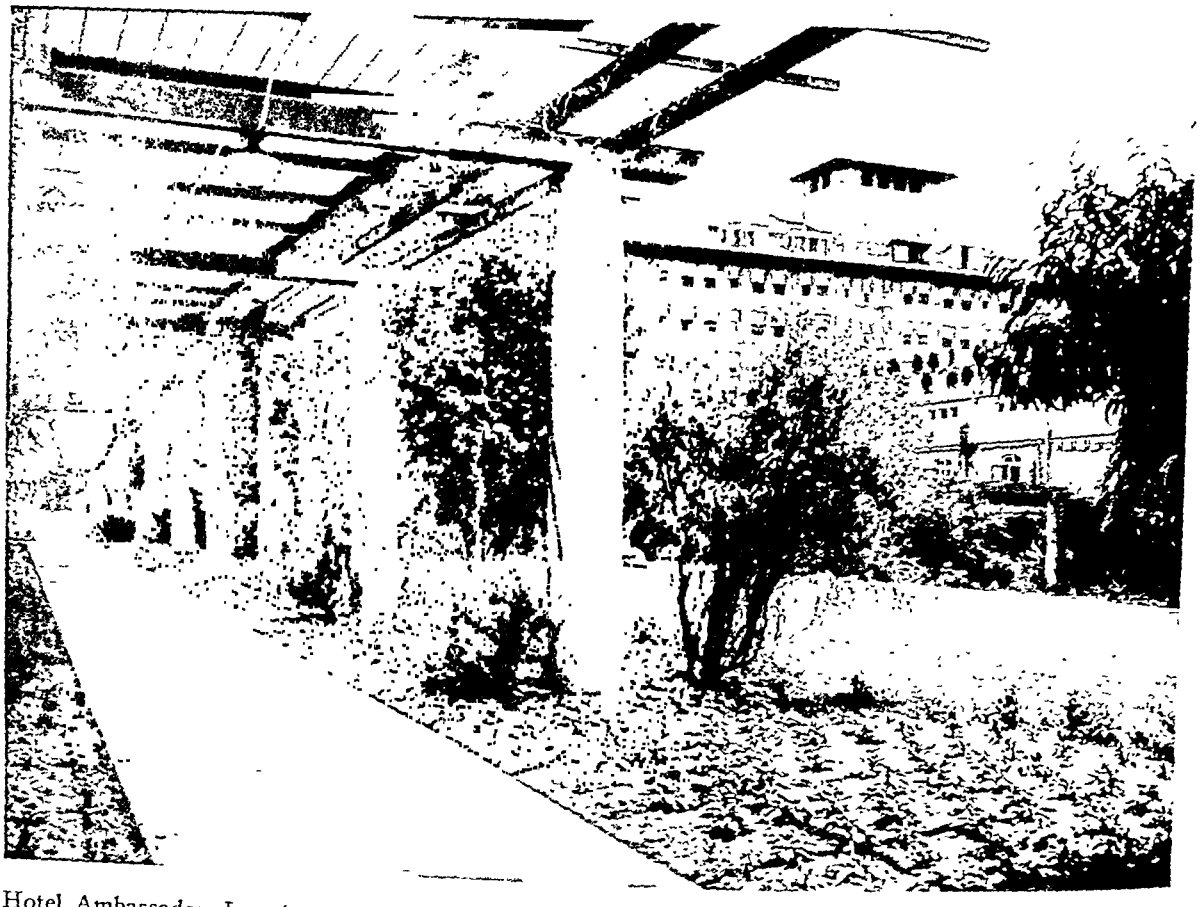
The work of the Congress will be divided into the following sections: (1) Roentgen Diagnosis; (2) Roentgenotherapy and Curietherapy; (3) Radiobiology; (4) Radiophysics; (5) Natural and Artificial Heliotherapy; (6) Medical Electrology.

In conformity with the regulations of the International Congress of Radiology, membership in the Congress will be open to (*a*) members of the national roentgen societies regularly constituted, and (*b*) persons accepted by these societies.

The officers of this Third International Congress are as follows: *President*, Dr. Antoine Béclère, Paris, France; *Vice-presidents*, Dr. J. Belot and Prof. C. Regaud, for Paris, and Prof. Cluzet and Prof. Rechou, for France outside of Paris; *Secretary-general*, Dr. Ledoux-Lebard; *Treasurer*, Dr. Henri de Rothschild; *Adj. Treasurer*, Dr. Morel-Kahn; *Secretaries*, Dr. Claude Béclère and Dr. P. Gilbert.

The registration fee for the Congress is 300 francs for each individual member, and 50 francs additional for each member of the family attending the Congress. Application blanks will be available at a later date.

The five delegates from the United States are: James T. Case, M.D., Chicago (American College of Radiology); Edwin C. Ernst, M. D., St. Louis, *Secretary of United States delegation* (Radiological Society of North America); Preston M. Hickey, M.D., Ann Arbor, Michigan (American



Hotel Ambassador, Los Angeles, the meeting place of the Sixteenth Annual Meeting of the Radiological Society of North America, Dec. 1 to 5, 1930.

Roentgen Ray Society); Albert Soiland, M.D., Los Angeles, *Chairman of United States delegation* (American Medical Association), and Douglas Quick, M.D., New York (American Radium Society).

Any one desiring more detailed information may feel free to write to either the Chairman or the Secretary of the United States delegation.

ANOTHER MEMBER OF THE SOCIETY HONORED

At the annual meeting of the Louisiana State Medical Society, Sidney C. Barrow, M.D., of Shreveport, was elected without opposition to the presidency for 1931. Dr. Barrow is widely known in the Radiological Society of North America, of which he has been a respected member since 1918. Radiologists are popular in Louisiana, and for good reason, since two other members of this Society have served their State Medical Society as president in former years—Leon J. Menville, M.D., of New Orleans, and Lester J. Williams, M.D., of Baton Rouge.

THE NEXT ANNUAL MEETING

An invitation is extended to members, friends, and all who are interested in radiology to attend the Sixteenth Annual Meeting of the Radiological Society of North America, to be held in Los Angeles, California, beginning December first and continuing to the evening of December fifth, 1930. The headquarters will be the Ambassador Hotel. The meeting rooms and accommodations for



Avalon Bay, Catalina Island, which may be easily reached by a brief "ocean voyage" from Los Angeles.

those attending will be as good or better than anything we have had at previous meetings.

The officers of the Society have spared no effort to prepare a program offering much helpful information, instruction, and interest. The Local Committee has made splendid arrangements with a view to the comfort and entertainment of those in attendance.

Our exhibitors who have been with us in the past will accompany us to the Coast, exhibiting the standard and the new in apparatus and accessories. In the informality of the exhibition space one renews and makes contacts of value in business, professional, and social life.

As always, the ladies of the families of the men in attendance are welcomed. They will enjoy the diversions planned by the Local Committee, and be given an opportunity to sample the climate of which we hear so much.

ROBERT J. MAY, M.D., *President.*

RADIOGRAPHY AND CLINICAL PHOTOGRAPHY

With the August, 1930, issue, the Eastman Kodak Company has changed the name of its house organ, previously known as "X-ray Bulletin and Clinical Photography,"

to the more truly descriptive one of "Radiography and Clinical Photography." The size of the publication has also been increased, with the aim of widening the scope of usefulness and interest of its departments of information. Its cover bears, together with a portrait of Professor Roentgen, the following dedication: "This publication is inspired by the humanitarian value of X-rays in the alleviation of suffering and the prevention of disease. It is dedicated to a continuation of the work made possible through discoveries by Wilhelm Konrad Roentgen and the pioneers of photography." Its Contents indicates much of real interest and instruction, and roentgenologists and their technical assistants may well form the habit of reading the little journal regularly.

IMPORTANT NOTICE

Application has been made for certificate plan convention rate to Los Angeles, and all who expect to return immediately after the meeting may, if they wish to risk paying full fare for return trip (if less than 150 certificates are validated), buy ticket to Los Angeles, secure convention certificate, and present the latter at the registration desk. If 150 certificates are presented for validation, return trip tickets may be purchased for half fare, but these must be used within two or three days, and over the same route as the trip to Los Angeles was made. *If less than 150 certificates are presented, full fare must be paid for the return trip. Purchasers take this risk.*

All-year tourist tickets are sold from all points in this country to Los Angeles, and are usable for return trip any time within nine months. We feel justified in recommending the purchase of these all-year tourist tickets, so that those attending will be sure of saving some considerable amount of the railroad fare. These all-year tourist tickets are good on all trains, standard Pullman and excess fare trains included, on payment of the Pullman rates and excess fare in addition.

See articles in May RADIOLOGY, page 517, and in September RADIOLOGY, page 410.

I. S. TROSTLER, M.D.
Manager of Commercial Exhibits and Transportation.

JOHN DONALD MACRAE

On the afternoon of September 6 Dr. John Donald MacRae, of Asheville, N. C., was fatally injured when the car in which he was riding with Mrs. MacRae skidded and overturned. Dr. MacRae died within a few minutes after reaching the hospital. Mrs. MacRae was not seriously injured.

Dr. MacRae has been Counselor for North Carolina for a number of years and has always taken a great interest in the Society. He was a Fellow of the American College of Radiology and the dean of radiologists in North Carolina.

John Donald MacRae, born in Fayetteville, N. C., March 10, 1874, was the son of James C. and Frances (Hinsdale) MacRae. His father was at one time Dean of the Law School at the University and Associate Justice of the Supreme Court of North Carolina. Dr. MacRae took his medical degree at the University of Nashville Medical School, in 1897. He married Miss Mary C. Hill the next year. He was in general practice for a number of years, first, in Winslow, Arkansas, and later in Fayetteville, N. C. In 1906 he moved to Tampa, Florida, where, after a few years' general work, he began the practice of radiology, continuing until 1917, when he entered the Army. After spending some time with Dr. Baetjer in Baltimore he served as radiologist in the Base Hospital at Camp McClellan and at Camp Greene, A. E. F., Base 54, and as

consultant radiologist he was at Mesves Hospital Center. Returning from France, he was radiologist for a year at U. S. A. General Hospital No. 19, Oteen, North Carolina. In 1920 he opened an office in Asheville, where, in connection with his private practice and several hospitals, he had continued as consultant radiologist at Oteen.

Dr. MacRae leaves a daughter and a son, Mrs. Carl S. Goodson and Dr. John Donald MacRae, Jr., the latter for the past two years having been associated with his father in the practice of radiology at Asheville, North Carolina.

Dr. MacRae was in reality a *physician practising radiology* and was always held in the highest regard by his confrères. His was a winsomeness that bound men to him "with hoops of steel." He will be sadly missed, not only in his own community but throughout the State and in the Radiological Society of North America, where his contributions were always received with interest and respect, for he spoke as one having authority and knowledge.

ACCOMMODATIONS AT THIRD INTERNATIONAL CONGRESS OF RADIOLOGY

As is already known to American radiologists, the Third International Congress of Radiology will be held in Paris, France, July 27 to 31, 1931. The further information has recently been received that the sessions are to be held in the Sorbonne.

Concerning hotel accommodations for those in attendance upon the Congress, the decision has been reached that no particular hotels are to be designated as headquarters, but that each one may select from the hotels of Paris that one which best suits his requirements. However, if one lacks information concerning rates, location, and style of accommodations available, he may learn much of interest by inquiring of the Chairman for the United States, Albert Soiland, M.D., 1407 South Hope Street, Los Angeles, California.

BOOK REVIEW

JAHRBUCH FÜR RÖNTGENOLOGEN, 1930. Bearbeitet von K. BRUMMER (Heidelberg), F. BURGHEIM (Berlin), H. CHANTRAINE (Betzdorf), R. DYROFF (Erlangen), L. GREBE (Bonn), A. HEDFELD (Magdeburg), G. HIN (Köln), K. KAESTLE (München), G. KOHLMANN (Oldenburg), F. PELTASON (Darmstadt), O. RIGLER (Hufeland, Darmstadt), ST. ROTHMAN (Budapest), A. SEYERLEIN (Elberfeld), F. SCHMITZ (Köln), J. SCHÜTZE (Berlin), M. SCHWARZ (Tübingen), W. STOCK (Tübingen), O. STRAUSS (Berlin), W. TESCHENDORF (Köln), K. WEBER (Köln), R. WERNER (Heidelberg), unter redaktioneller Leitung von O. RIGLER (Hufeland, Darmstadt). Verlag Walter de Gruyter & Co., Berlin and Leipzig, 1930. Gross-Oktav, 220 Seiten, Preis RM. 12.–, geb. R. M. 13, 50 (3.24).

This book introduces a new idea into the book market. It endeavors to arrange in reference form the roentgenologic literature of the past year. The men reviewing the different chapters have been left free to make their own critical selection among the publications. The intention of this and subsequent volumes is to make available the most important of the numerous published articles and to have them reviewed critically in a more or less personal manner. The physician who is interested in roentgenology and who cannot read all the literature has by this means a chance to orient himself rather speedily and to see if he has missed something important in his field. The names of the authors guarantee almost throughout an efficient review of the differ-

ent chapters. I have read some chapters with especial delight, for instance, that of Kaestle (München), about the roentgen diagnosis of the respiratory tract, including the mediastinum and diaphragm; that of R. Werner (Heidelberg), about radium therapy, and that of O. Strauss (Berlin), concerning malignant tumors. One finds, furthermore, some chapters about physical and technical problems, diagnosis in the different fields, and, finally, about therapy in its different branches. Each chapter has its own bibliography of the contributions pertaining to it.

F. HAENISCH (Hamburg, Germany).

Translation by H. W. HEFKE, M.D. *(Milwaukee, Wisc.).*

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APPENDIX (DIAGNOSIS)

The Chronic Appendix from the Roentgenological Standpoint. Adolph Henriques. New Orleans Med. and Surg. Jour., July, 1930, LXXXIII, 29.

By chronic appendix is meant one which has been subjected to repeated acute attacks, according to MacCallum, or one which is chronic from the beginning of the inflammation. Stagnation in the appendix is an important factor in producing inflammation. The stagnant appendix can be demonstrated fluoroscopically to better advantage than by roentgenograms. The appendix fills by retrograde peristalsis, which exists normally in the colon; when this becomes increased, as in spastic constipation, it will fill the appendix. The appendix varies widely in location, and when the palpating finger elicits pain over the filled appendix this is of great diagnostic importance. When not visualized, palpation over the cecum may show points of tenderness corresponding to the location of the appendix. In the production of appendicitis, the writer classifies the following steps in the evolution of the condition: right-sided stasis in colon; increase of retrograde movement of proximal colon; stagnation in the appendix; appendicitis.

W. W. Watkins, M.D.

A Study of the Cause of Right-sided Abdominal Pain in So-called Chronic Appendicitis: A Review of 1,027 Cases. W. A. Bigelow. Canadian Med. Assn. Jour., July, 1930, XXIII, 22.

This series of cases is interesting not only for the end-results, but also for the points in diagnosis and the X-ray methods employed in arriving at a diagnosis.

Emphasis is laid on the fact that chronic right-sided abdominal pain is not often due simply to chronic appendicitis. Pulling or pinching the appendix or its mesentery causes cramps, while traction on the peritoneum through membranes or bands produces the pain of which patients complain. The pain is produced through the pull on the peritoneum, and differs from appendiceal pain in that it is chronic and dull and not acute and cramp-like. Hence, the surgical method which simply removes the appendix fails in most cases to remove the chronic pain. There must be a thorough removal of all bands and membranes covering the region of the bowel involved, as well as the appendix.

The diagnosis was made by the X-ray, and was in every case due either to bands of the cecum or ascending colon or terminal ileum, or some combination of these. The X-ray work was done in the Bigelow Clinic by the writer. The results recorded are most encouraging. Ninety-three per cent of the patients, reporting in answer to a questionnaire, stated that they were completely cured of their right-sided abdominal pain as the result of the removal of bands and membranes. The operation and the after-treatment are described in detail.

L. J. Carter, M.D.

Chronic Appendicitis: Diagnosis and Significance. Thomas R. Brown and Ernest H. Gaither. Southern Med. Jour., July, 1930, XXIII, 591.

After years of close study of subjective symptoms, objective signs, biopsy, and the continued pre-operative and post-operative observation of numerous cases, these authors are convinced that the pathological entity of chronic appendicitis occurs. As an adjunct to the objective and subjective findings, X-ray is valuable. The method is to administer barium 18 hours before the first fluoroscopic observation, when the patient is carefully studied under the horizontal screen. Then the colon is emptied with a saline, and further careful studies are made. At both times the morphological and sensory characteristics are noted, and these findings, plus the clinical history, subjective and other objective findings (physical and laboratory), will enable the physician to arrive at a dependable conclusion regarding the appendix.

W. W. Watkins, M.D.

BLOOD CHANGES

The Effect of Roentgen Rays on Cholesterol and its Fatty Acid Esters *in Vitro* and *in Vivo*. Rudolf Hummel. Strahlentherapie, 1930, XXXVI, 533.

The fatty acid esters of cholesterol dissolved in chloroform, as well as free cholesterol, can be destroyed by roentgen rays. Cholesterol dissolved in fat or in blood serum, if irradiated *in vitro* by roentgen rays, with a dose of 1,650 r, does not show any changes. The liver of normal mice, as well as the liver of mice following cholesterol feeding, shows the same amount of cholesterol content before and after exposure to roentgen rays, with a dose of 1,100 r.

ERNST A. POHLE, M.D., PH.D.

Changes in Catalase and Lipase in the Blood of Irradiated Patients. M. J. Goldstein and J. P. Neworoschkin. Strahlentherapie, 1930, XXXVI, 736.

A number of ferments were determined in the blood of patients following exposure to roentgen rays. The amount of catalase was found increased, while lipase increased in some and decreased in others. There is apparently a correlation between the amount of ferment fluctuation and the irradiated organ. The catalase, for instance, showed most characteristic changes following irradiation of the lymphatic system. There was no parallel between the character of the ferment curves and the disease. Further studies are under way.

ERNST A. POHLE, M.D., PH.D.

BONE (DIAGNOSIS)

Calcium Rings in Growing Bones. Anton Gottesleben. Röntgenpraxis, Aug. 1, 1930, II, 673.

The conclusions reached by the author from his observations indicate that growth in bones is not regular. Rather, it is dependent on different factors, and is most marked in the warm seasons and least marked in the cold. The growth optimum during the warm season may be explained by the action of the ultraviolet rays during this season. This irregularity of bone-growth leads to the formation of roentgenologically demonstrable shadows and rings in the skeleton, which are localized around the growth-centers, if certain conditions are favorable. Exogenous and endogenous causes may lead to either increase or decrease of bone-growth. Hyperemia, prolonged rest, and changes in diet must be considered as exogenous causes; the action of the endocrine system and its pathologic changes as an endogenous cause. A pathologic process localized in the zone of bone-growth, and a disturbance in the calcium resorption are factors which may produce calcium rings in the skeleton.

A great number of instructive film reproductions are added to this article.

H. W. HEFKE, M.D.

Chondroma of Intervertebral Disk. Paul C. Bucy. Jour. Am. Med. Assn., May 17, 1930, XCIV, 1552.

A review of the literature is presented, with a report of one case. The majority of cases reported have been in the cervical region; the author's case showed involvement of the disk between the third and fourth lumbar.

The report covers the history, examination, operation, and histologic study of the specimen, and an interesting comment follows. It makes a very comprehensive review of this subject.

C. G. SUTHERLAND, M.D.

Fracture of the Neck of the Femur: The Importance of Correction of the Outward Rotation of the Leg. E. B. Mumford. Jour. Indiana St. Med. Assn., July, 1930, XXIII, 316.

A study of the roentgenogram of the normal hip is essential to interpretation of the conditions in the fractured hip. In the normal hip, with leg in position of neutral rotation, the neck of the femur is fairly long, the greater trochanter is some distance from the

rim of the acetabulum, and little of the lesser trochanter is shown. After fracture of the neck of the femur, the femoral angle will be 90 to 100 degrees, instead of the normal 120 to 130 degrees. This is due to abduction of the inner fragment and adduction of the outer fragment. The fractured surfaces are not in contact, and must be brought in contact by correcting the outward rotation of the leg, by bringing the leg (outer fragment) into a position of neutral or slight internal rotation. Abduction alone will not reduce the fracture, but merely corrects the angulation.

W. W. WATKINS, M.D.

Phalangeal Pseudo-epiphyses. J. Becker. Röntgenpraxis, June 15, 1930, II, 559.

Beside the pseudo-epiphyses on the metacarpals Becker describes multiple phalangeal pseudo-epiphyses in two children, who had the clinical signs of a Mongolian idiocy, and in another child, who was clinically entirely normal. Such findings are probably not as rare as the lack of reports would indicate, and it would be desirable if the roentgenologist would look more frequently for such changes.

H. W. HEFKE, M.D.

A New Technic for a Roentgenogram of the Scapula. Rudolf Wahl. Röntgenpraxis, July 15, 1930, II, 652.

The antero-posterior and lateral roentgenograms of the scapula are not entirely satisfactory. The author describes a technic which appears to show the scapula in its entirety in the X-ray film. The patient lies on his back, with his arm abducted and rotated outward. The X-ray tube is tilted so that the central ray forms an angle of about 130 degrees, with the film under the shoulder of the patient. One could call this technic a lateral-ventro-dorsal exposure.

H. W. HEFKE, M.D.

The Radio-ulnar Synostosis. Hans Hefter. Med. Klinik, Aug. 8, 1930, XXVI, 1184.

Two types of radio-ulnar synostoses may be distinguished: the congenital type and the traumatic type. The symptoms of these two types are alike and consist in inability to rotate the forearm. The congenital synostosis may be bilateral and familial, and the knowledge of its existence may be of importance in industrial surgery.

H. W. HEFKE, M.D.

BONE DISEASES (DIAGNOSIS)

Gonorrheal Spurs a Misnomer. William H. von Lackum and Emilio J. Palomeque. Jour. Am. Med. Assn., August 16, 1930, XCV, 472.

One hundred consecutive cases of exostosis of the os calcis were reviewed. In 6 per cent there was no accompanying pain. Pain, when present, was directed to the heels in 55 per cent, and to the feet in 39 per cent.

A history of gonorrhea was obtainable in only 44 per cent of the cases. In only 2 per cent the onset of pain was a few days to three months from the onset of the gonorrhea. In 56 per cent pain post-dated the gonorrhea by an average of fourteen years. Eight patients without gonorrhea and four patients with gonorrhea also had osteo-arthritis of other joints. Syphilis, as far as could be ascertained, was not an etiologic factor in any of the cases.

A variety of etiological factors for calcaneal spurs have been commented on by vario servers. Neither syphilis nor gonorr gross factor in the etiology. The te orrheal spurs" is a misnomer be used.

CHARLES G. SU

The Arthritic C rrhea in the Adult Male. and Leon Solis-Cohen. June, 1930, CLXXIX,

The authors report arthritis, with special the course of the dis tis appeared, its chron functional results.

In only two of thi

findings indicate that the prostate was the site of the focal infection. In the other 26 cases the clinical evidence indicated that the seminal vesicles were the site of the focal infection.

In three cases which developed during acute gonorrhea the arthritis was comparatively mild and the vesicles palpable but not hot. In eight cases with typical acute gonorrheal arthritis the seminal vesicles were palpable and hot. The arthritis was bilateral in five cases. Of the acute cases, there were five in which joint disability followed the acute gonorrheal arthritis.

In five cases in which arthritis developed subsequent to apparent cure of gonorrheal arthritis there was infection in the vesicles. In all of these there was some joint disability.

There were seven cases in which arthritis developed after the clinical cure of gonorrhea. All of these cases showed definite infection of the vesicles, but the vesicles were not hot to rectal palpation.

The authors draw the following conclusions: Arthritis due to gonococcal infection of the vesicles differs from arthritis due to non-gonococcal infection of the vesicles only in degree of intensity of the resulting joint lesions. The two types exhibit the same predilection for the larger joints; are both likely to involve several joints, and tend to spontaneous cure of some of the involved joints, with persistence in others.

ROE J. MAIER, M.D.

Fragility and Deficient Healing of Bone in Poliomyelitis. I. Harrison Tumpeer and R. W. McNealy. Jour. Am. Med. Assn., July 5, 1930, XCV, 19.

In a paralyzed member, bone atrophy runs parallel with the muscle-wasting and proceeds with modification in the size of the vessels of the region and the structure of the subcutaneous tissues. Two cases are reported in which atrophy, tendency to fracture and regeneration were all related to the poliomyelitic lesion.

The authors come to the following conclusions: (1) Bone atrophy in poliomyelitis is indistinguishable from bone atrophy from non-use; (2) atrophic bones are easily fractured; (3) callus formation occurs in fractures of parts affected by poliomyelitis; (4) callus in such parts produces weak union because the functional stimulus is absent.

CHARLES G. SUTHERLAND, M.D.

Gonorrheal Infection of Bone. H. E. Bardenwerper. Jour. Am. Med. Assn., April 19, 1930, XCIV, 1230.

The author reports a case of gonorrheal infection of bone in a female. Stark reviewed all cases up to 1913 (the reference is given), and rated it as a rare condition. In his own case the author felt that earlier roentgenograms might have saved considerable inconvenience to the patient and worry to the doctor. The end-results seem to have warranted the conservative treatment carried out.

CHARLES G. SUTHERLAND, M.D.

BONE DISEASES (THERAPY)

Osteogenesis Imperfecta Tarda (Fragilitas Ossium): Report of Four Cases in One Family. Morris Gleich. New York St. Jour. Med., July 15, 1930, XXX, 850.

Since only bone tissue is affected, it would seem to be due to an impaired bone-forming mechanism in the embryo. In a family composed of a father, mother, and six children, the father and three of the children show evidences of this affliction. Judging by X-ray appearances, rickets, osteogenesis imperfecta, and osteomalacia show similar osseous responses of varying degrees. Perhaps Vitamin D, with diet liberal in calcium, would be of benefit in all of these diseases.

W. W. WATKINS, M.D.

Osteochondritis of the Growth Centers. Maxwell Harbin and Robert Zollinger. Surg., Gynec. and Obst., August, 1930, LI, 145.

The authors of this article state: "The purposes of this paper are (1) to [illegible] re-

view of the literature concerning a disease common to all the centers of ossification of the human skeleton; (2) to simplify and standardize the terminology of this disease, and (3) to present its occurrence in a family of four individuals."

They feel that the pathological entity of osteochondritis, described by Osgood, Schlatter, Koehler, Legg, Calvé, Perthes, Freiberg, Scheuermann, Kienboeck, and others as located in particular epiphyses, has a similar or common cause; attaching the name of the early writers has caused confusion in the terminology of the one basic disease. Osteochondritis is divided into two distinct groups, primary and secondary, depending upon whether the primary center of ossification or the secondary center is first involved.

An excellent drawing is shown of the ossification centers, with the ages of appearance and final ossification, with dates indicating when the diseases were first described, and the authors who first reported them. The primary type may continue until the appearance of the secondary centers, or both types may appear simultaneously in the same patient. The disease is limited by complete ossification.

The more common locations are discussed, including terminology, symptoms, roentgenologic findings, prognosis, and treatment. Case reviews of the hip, patella, humerus, and four cases of spine involvement in members of the same family are given. Both primary and secondary types of osteochondritis are represented in the cases of spine involvement, the secondary cases representing the disease in the initial, active, and arrested stages.

The etiology of the disease is unknown. However, direct trauma, or indirect trauma as a result of increased stress and strain from the body forces, appears to play an important rôle. Heredity may be considered as a possible etiological factor as considered by Hanson and represented by the authors' series of four members in one family having involvement of the spine. Leriche and Policard offer an explanation from vasomotor changes based on the reflexes of the traumatized axone. Perhaps a combination of the factors, added to some unknown cause, may be found to be responsible for this disease.

The treatment varies according to the location of the disease. In general, a period of physiological rest of from four to six weeks is essential. When plaster supports are dispensed with, some mechanical device may be used to prevent recurrence of the deformity until the period of active growth of the center involved is over. It is thought that chronic arthritis may develop in the involved areas in later years.

D. S. CHILDS, M.D.

Diabetes Insipidus and Osteitis Fibrosa Polycystica. Abraham Sophian. Jour. Am. Med. Assn., August 16, 1930, XCV, 483.

This is a report of a case, with a short review of the literature. Interesting observations have appeared in the literature on the relationship of parathyroid disease (*hyperparathyroidism*) to generalized bone disease, and notably to osteitis fibrosa polycystica. Most writers agree that hyperparathyroidism produces a hypercalcemia, the calcium being extracted from the bones, thereby producing bone disease. In turn, there is excessive excretion of calcium, and metastatic calcium deposits have been found in the lungs, kidneys, stomach, heart muscle, and thyroid.

Improvement in the bone decalcification has been reported by some observers after the removal of parathyroid tumors. The only specific remedy is pituitary extract, which controls the polydipsia but has no effect on the bone lesions.

CHARLES G. SUTHERLAND, M.D.

BONE TUMORS (DIAGNOSIS)

Multiple Myeloma. C. T. Burnett and W. C. Johnson. Colorado Med., June, 1930, XXVII, 178.

The early sites of involvement of this neoplasm are the flat bones, ribs, and vertebræ, extending later to other organs. The early clinical symptoms are rheumatic pains, often ascribed to neuritis, aggravated by exertion. Often a spontaneous fracture will be the first

suggestion of bone involvement. The condition must be differentiated from osteitis fibrosa and metastatic malignancy. Myeloma occurs usually in older persons, being a slow-growing multiple lesion of the flat bones which produces sharply outlined focal spots of destruction. The X-ray appearances may be indistinguishable from those of metastatic malignancy. A pathological examination of a section of the bone removed for biopsy may be done.

A case record, with autopsy findings, is included in the paper.

W. W. WATKINS, M.D.

Osteitis Fibrosa Cystica, Generalized Type, with Giant-cell Sarcoma. Benjamin M. Joseph. Am. Jour. Dis. Child., July, 1930, XXXX, 81.

Cases of this condition have been noted in the literature since 1840. Von Recklinghausen gave his classic description of the disease in 1891, at which time he reported three cases. Morton's division of the cases into two groups is as follows and has proven to be valuable: (1) cysts without giant-cell sarcoma, (2) cysts with giant-cell sarcoma.

The author describes a case of osteitis fibrosa cystica in a child thirteen months of age. The rapidity with which the lesions became evident was most striking. The first series of roentgenograms demonstrated involvement of the right mandible, skull vault, and distal portions of the femora. Five weeks later there was definite extension of the cystic condition in the femora, and within two months the entire skull vault, clavicles, ribs, humerus, iliac and pubic bones, femora, and tibiæ were involved. There was a severe anemia present. The histologic diagnosis was metastatic large round- and giant-cell sarcoma.

The changes in the contour of the long bones, the widening and irregularity of the cortex and marrow cavity, the translucent shadows of honey-combed appearance in the cystic areas, lack of involvement of the joint surfaces, epiphyses, and periosteum are considered the main characteristics essential in the roentgen diagnosis of the condition. In the roentgenograms shown by the author, there was noted definite periosteal elevation in the femora.

The etiology of the condition is somewhat obscure. Trauma, toxicity, and disturbance of the internal secretory organs have all been considered. Erdheim believes that parathyroid disease is a strong etiologic factor. The condition is certainly unusual in children.

F. B. MANDEVILLE, M.D.

A Contribution to the Knowledge of Chondromatosis. Helmut Stark. Röntgenpraxis, Aug. 1, 1930, II, 717.

A woman forty-three years of age presented very marked chondromatosis through almost the entire skeleton. The typical roentgenologic appearance is described. Calcification of the cartilaginous tumors is rather marked, but the tendency to further growth and the possibility of sarcomatous degeneration make the prognosis rather doubtful, in the author's opinion.

H. W. HEFKE, M.D.

Hereditary Deforming Chondrodysplasia: Report of a Case. Olan R. Hyndman. Arch. Surg., July, 1930, XXI, 12.

This condition has been commonly referred to as multiple cartilagenous exostoses and has been described under various other names. It is hereditary and familial, having been traced through five generations in several instances. A definite etiological factor has not been established, but certain facts are well known. Cartilage rests are left in the wake of a chaotic advancing epiphysis and these rests undoubtedly form the nucleus of the anomalous benign tumor. Nearly all the bones of the body, with the exception of the skull, are involved.

There is often a disproportionate development of the bones of the forearm and of the lower leg, the ulna and fibula being considerably shortened and distorted with respect to the radius and tibia. The tumors vary in their bone content, but are practically always less dense than the adjacent normal bone. They

are centrally located and expand the cortex, in some respects resembling giant-cell tumors of bone. Cases of malignant degeneration of enchondromas have been reported in the literature, but comprise only about 5 per cent of these hereditary cases.

The author does not believe in a possible kinship of chondrodystrophia fetalis and hereditary deforming chondrodysplasia. He reports one case in detail.

HOWARD P. DOUB, M.D.

Hereditary Deforming Chondrodysplasia or Multiple Exostoses: Report of a Father and Two Daughters Showing Similar Multiple Symmetrical Exostoses, and Fifty Other Cases Collected from the English Literature Since 1917. Kelley Hale. Ann. Surg., July, 1930, XCII, 92.

The author reports in detail three cases of multiple exostoses occurring in a father, 58 years of age, and two daughters, 18 and 15 years of age, respectively. A third daughter and a son presented normal skeletal development.

The various possible etiologic factors are discussed at length. Several theories adced by authors who have reviewed the litture, are considered. Hale states that in he three cases studied by him, heredity unquestionably exists as an etiologic factor, and he adds, "Multiple exostoses may be due to impressions made upon the germ plasm consequent to fractured bones and their complex healing processes in past generations." In proof of his evolutionary theory, he presents statistics of a series of fractured bones in his own practice.

In Ollier's disease, the shortening of the extremities affects only one side of the body, while in chondrodysplasia it is generally symmetrical. Hale believes that a few years' study into the geneology and offspring of this small group of individuals would clear up the much disputed point of whether or not Ollier's disease is a distinct clinical entity.

F. B. MANDEVILLE, M.D.

BONE TUMORS (THERAPY)

Treatment of Osteogenic Sarcoma of Long Bones. W. H. Gibbon. Jour. Iowa St. Med. Soc., July, 1930, XX, 297.

Many investigators, notably Bloodgood, Coley and Eissing, have considered irradiation of little or no benefit in these cases, and the question naturally arises as to the reason for this attitude. Radiation is still in its infancy, and from results which are available it would seem that roentgen-ray therapy is of distinct value in the treatment of osteogenic sarcoma, preliminary to surgical removal, as evidenced by definite prolongation of life in the irradiated cases when compared with the non-irradiated cases. Five-year cures are possible, even when metastases are present, as illustrated by a case cited.

W. W. WATKINS, M.D.

Statistical Review of Tumors of the Limbs Observed in Rizzoli's Orthopedic Institute during the Years 1927-1928. Giulio Faldini and Oscar Scaglietti. Rivista di Radiologia e Fisica Medica, March, 1930, II, 265.

This is a review of thirty-two cases of the limbs seen in Rizzoli's Institute and includes notes on the treatment and radiographic and anatomic findings in these cases. Four benign tumors were treated surgically; ten metastatic lesions had radiotherapy, usually with resulting relief of pain; of eighteen malignant tumors three were extirpated surgically, the others, after surgical removal, had prophylactic roentgen treatment locally and to the lungs. Three cases had Coley's toxins without subjective or objective change.

E. T. LEDDY, M.D.

CANCER (DIAGNOSIS)

Cancer of the Stomach. Ralph H. Chaney. Jour. Med. Assn. Georgia, June 1930, XIX, 222.

This is a fairly detailed description of stomach cancer, covering various phases. From the

standpoint of diagnosis, any individual over forty years of age who comes with a complaint of dyspepsia, biliousness, or indigestion should be suspected of cancer until it is ruled out. Likewise, no case should be allowed to run along with a single examination following a persistent loss of weight, but should have frequent check-up studies by X-ray, gastric analyses, examination of the stools for occult blood, and weighing. The most valuable single aid in the diagnosis of gastric cancer is the roentgen-ray study. The characteristic cases show definite findings, ulcers having diameters of more than 2 cm. being malignant three times out of five. When characteristic X-ray findings exist, clinical signs are present in 91 to 95 per cent of the cases, these being indicated by changes in gastric contour in 93 per cent, by the presence of a mass in 73 per cent, and by variation in the gastric acids in 88 per cent.

W. W. Watkins, M.D.

The Impending Developments in the Diagnosis and Treatment of Cancer. Francis Carter Wood. Ohio St. Med. Jour., July, 1930, XXVI, 589.

Not over 20 per cent of the persons applying for relief to a large private hospital are operable or capable of receiving effective treatment by X-ray or radium; and of the 20 per cent who are operable, scarcely more than 5 per cent obtain what we call a cure. That is why the death rates from cancer mount steadily. It is astonishing how ignorant the people are regarding the therapeutic resources for cancer. The disease should be made notifiable, so that people may be instructed through the proper channels, instead of being misinformed by the ignorant. The profession must learn to seek the best possible aid in treatment, instead of following personal loyalties. There should be institutions in every large community where cancer patients can be treated by the best surgical and special skill available. While every case of cancer cannot be referred to such an institute, as is the case in Sweden, both the public and the profession would gradually learn to refer their patients where they could best be treated by surgery or radiation.

W. W. Watkins, M.D.

The Cystic Carcinomatosis of the Skeleton and Several Other Types of Generalized Carcinomatosis of the Skeleton in the Roentgen Picture. H. Meyer-Borstel. Röntgenpraxis, July 1, 1930, II, 604.

Four different types of generalized carcinomatosis of the skeleton are described, each one of which gives an entirely different X-ray appearance, according to the predominance of osteoclastic or osteoplastic bone processes. Generalized cystic carcinomatosis of the skeleton is rarely observed. Its diagnosis may be very difficult, as other cystic bone diseases may give the same picture (multiple myeloma, osteitis fibrosa cystica). The generalized purely osteoplastic type of metastasis is sometimes hard to differentiate from a genuine osteosclerosis (Albers-Schönberg's marble bones), while the mixed types with osteoplastic as well as osteoclastic processes usually do not present any differential diagnostic difficulties. A very marked contrast may exist between the extension and severity of generalized bone metastases and the good general condition of the patient, so that the clinician often does not think of a generalized metastatic bone involvement.

H. W. Hefke, M.D.

Contribution to the Clinical and Roentgenological Diagnosis of Lung Carcinoma. Karl Herman. Wien. klin. Wchnschr., July 17, 1930, XLIII, 910.

While the clinician could make a definite diagnosis of lung carcinoma in about only 2 per cent of the cases twenty years ago, one can do so to-day in about 70 per cent. This remarkable progress is mostly due to the modern roentgen diagnosis. In questionable clinical and roentgenologic cases, one should use the bronchoscope and sometimes rely on the reaction of questionable lung tumors to ther-

apeutic doses of X-rays, in order to make a differential diagnosis.

Twelve cases are described, with clinical and roentgenologic findings.

H. W. HEFKE, M.D.

CANCER (THERAPY)

Report on the Results of the Genital Carcinomas Operated on and Irradiated during the Period from 1917 to 1927, and on the Cure of a Case of Vaginal Sarcoma in a Child. Anselm Reisach. Strahlentherapie, 1930, XXXVII, 341.

During the period from 1917 to 1924, 178 cases of inoperable carcinoma of the cervix were seen in the author's clinic. Sixteen remained untreated and they all died; thirty-two received only radium treatment and all patients died; 130 cases received radium and roentgen rays combined (12 were still alive after five years). This corresponds to a relative cure in 10 per cent. Fifty operable cases of carcinoma of the cervix were treated by irradiation; 12 of these patients were still alive after five years, corresponding to 24 per cent cures. Sixty cases were operated on and then irradiated. The primary mortality was 10 per cent, with 35 per cent cures after five years. Twelve cases were treated by amputating the cervix, followed by X-ray and radium. Eight died and 4 are still alive after five years. From a total of 300 cases of operable and inoperable carcinoma of the cervix, 15 per cent were well following operation or irradiation after the five-year period. A statistical survey is also given of the cases seen during the period from 1925 to 1927. It appeared from the three years' observation that the majority of deaths due to recurrence take place during the first three years. Since the mortality of the operation rises considerably if borderline cases are included in the operative list, the author prefers stricter indications for surgery.

During the period from 1917 to 1925, 9 carcinomas of the fundus were seen, 6 of which were operated on and 3 were treated by X-ray and radium. Four of the cases operated on and 1 of the irradiated cases were free of recurrence after five years. During the same period, 33 cases of carcinoma of the ovary were admitted, 2 of which were free of recurrence after five years, 1 following operation and 1 following irradiation. Of the 12 cases of carcinoma of the vulva, all died (1 patient after five years and three months). There were 9 cases of carcinoma of the vagina, 2 of which were free of recurrence after five years. These were treated by excision of the tumor, followed by radium and roentgen therapy.

In conclusion, the history of a two-year-old girl is briefly related, who had a pedunculated sarcoma of the vagina. This was removed, followed by intravaginal radium application. The patient is still free of recurrence three years following the treatment.

ERNST A. POHLE, M.D., PH.D.

The Care of Carcinoma Cases in Schleswig-Holstein. Rob. Schröder. Strahlentherapie, 1930, XXXVII, 378.

Medical Education in the Fight Against Carcinoma. W. Lahm. Strahlentherapie, 1930, XXXVII, 386.

The Rôle of Radiation Therapy in Social Gynecology. Wilhelm Liepmann. Strahlentherapie, 1930, XXXVII, 402.

In these three papers, problems of the fight against carcinoma are discussed from the viewpoint of State administration, of medical post-graduate education, and from the economic standpoint.

ERNST A. POHLE, M.D., PH.D.

The Treatment of Cutaneous Malignancies. Harry R. Foerster. Wisconsin Med. Jour., July, 1930, XXIX, 361.

There is no therapeutic measure of preference in the treatment of skin cancer, generally applicable. Surgery, electrothermic surgery, radium, and X-rays are all applicable. Success in treatment necessitates an intimate knowledge of the various measures, judgment in the method of choice, and experience and skill in application. The types of lesions include the locally malignant (*e.g.*, the basal-cell), and the generally malignant or metastasizing (*e.g.*, the prickle-cell). In basal-cell

epithelioma, X-rays and radium give the best results and should have preference; if supplementary treatment is required, endothermy is best. Early lesions of the squamous-cell type are usually successfully treated by radiation, but advanced lesions require electrothermic destruction in addition. Epitheliomas of the mucous membranes or at the mucocutaneous junction are best treated with radium, unless infected, when they are best treated by surgical or combined methods. Nevocarcinomas require wide excision with scalpel or surgical endothermy. Destruction by endothermy, even when considered complete, is preferably followed by X-rays or radium in dosage sufficient to destroy any remaining cancer cells.

W. W. WATKINS, M.D.

Cancer of the Lip, Tongue, and Skin: A Statistical Inquiry. Janet Lane-Claypon. Lancet, Aug. 2, 1930, CCXIX, No. 5,579, p. 260.

These statistical inquiries were made by the author and published as No. 59 of the Reports on Public Health and Medical Subjects issued by the Ministry of Health. In considering treatment the percentage of results is mostly set out in the form of two different survival-rates, the crude and the net. The crude rate regards all cases not definitely known to be alive and well as having died of cancer, and gives too unfavorable a result. In calculating these rates no patient has been included among the living, who, though alive, was known to have a recurrence of the disease. A survey of the literature on operability of cancer of the lip shows that only 10 per cent of the patients who apply for the treatment are in an inoperable stage. Operative mortality is not a serious factor, except in advanced cases where removal of bone is necessary. The net survival-rates are 29.4 per cent for five years, and 58.4 per cent for three years. In cases in which the glands were removed the survival-rate was 80 per cent, and there was no great difference between the three-year and five-year rates, for 90 per cent of recurrences take place within three years. For all stages of the disease and for all methods of radiotherapy, the survival-rate was 76.1 per cent at three years after treatment. The results of treating recurrent cases are good enough, either by operation or by radiotherapy, to make treatment worth undertaking.

Cancer of the lip takes a slow course if it is not treated, and there are cases on record in which the symptoms had been present for thirty-six years. Most patients report for treatment within one year of the onset of symptoms. The lower lip is more often involved, the proportions being 95 to 5. It occurs twelve to fourteen times more often among men than among women, but women are more apt to have cancer in the upper lip. The average age of application at hospitals is 57 years, and the average age at death is 70 years. Metastases are rare. The data which have been collected do not support the common belief that smoking has an etiological relationship to cancer of the lip. In 184 cases investigated, roughly one-quarter were affected with cancer at the place where they held their pipes. The commonest precursory lesions are blebs and ulcers.

The literature on cancer of the tongue was found to give unsatisfactory data for the purposes of the report, and the results are to be considered as only relatively accurate. Apparently from 20 to 25 per cent of all patients operated on are alive and well three years later, but the true survival-rate is probably somewhat higher than this. The operative mortality rate varies from 7 to 12 per cent. The examples available suggest that radiological treatment shows a better survival-rate than operation—37.8 per cent and 59 per cent in a small group from the Radiumhemmet, Stockholm. The disease, on the whole, has a short natural duration, about sixteen months. Patients usually apply for treatment seven to eight months after the appearance of symptoms, and delay is all the more serious in that the disease has such a short natural period and disseminates so rapidly. It reaches glands early in its course, and most surgeons prefer to treat them as part of the routine. The mean age of occurrence is 54 years, and of death is 61. Cancer of the tongue is about ten times as common among men as among wom-

en. The commonest antecedent condition recorded is syphilis. There is also a close relationship to leukoplakia, with or without previous syphilis. There are no accurate data of the supervention of cancer upon syphilis. So far as the figures go, there is no definite association between smoking and cancer of the tongue, and while the jagged edge of a tooth seems to have been an exciting cause in a few cases, statistics dealing with dental abnormalities are too scanty to be worth consideration. In some parts of the East—but not in other parts—betel-chewing seems to produce cancer of the mouth, and the literature does not indicate whether the difference is due to some variety in the composition of the quid or to different habits of chewing.

There is a wide variation in survival-rates of cancer of the skin, but on the whole it appears that from 40 to 50 per cent of all patients treated are alive and well three years after operation, and there is little doubt but that adequate radiologic treatment will give a figure of from 80 to 90 per cent. Despite differences of opinion the results appear to be more favorable with basal-celled than with squamous-celled cancers. Radiotherapy gives good results with relapsed cases. The disease takes a long course, the average period between the appearance of symptoms and the application for treatment being ten years. Less than 25 per cent of patients apply within a year. Most lesions occur in the upper part of the head and face, and the majority of these are basal-celled, invading the glands very slowly, if at all.

A few cases of sarcoma have been unavoidably included. Radiotherapy seems to give good results in sarcomata and melanotic sarcomata. Men and women are affected about equally, with a slight preponderance among men. The mean age varies between 55 and 58, and the mean age of death is 66 for men and 68.7 for women. The precursors are blebs, crusts, warts, pimples, scabs, nodules, or injuries. It seems reasonably certain that a high percentage, if not all, of cancers of the skin, develop on a previously existing lesion, and that many of them are caused by frequent irritation. The relationship of occupation to cutaneous cancer has been exhaustively investigated, chimney-sweeping and mule-spinning being the two occupations which show a high percentage of deaths from cancer of the scrotum. There is insufficient evidence for laying much stress on the relationship of the disease to climate, whether to cold, heat, or general exposure.

Cancer of the penis and scrotum form a large part of all deaths attributable to cancer of the skin. The results of treatment of cancer of the penis are very satisfactory, but there are no data available from any general hospital in England. Statistics from abroad show that the crude survival-rate after three years is 47.4 per cent, and after five years 41.1 per cent. It is probable that the results of radiotherapy are as good as those of surgery, although there are no large series to be studied. The average period from onset of symptoms to treatment is 14 months, and the interval is often extended to two years by preliminary ineffective treatment at home. There is a high proportion of cases showing enlarged but not yet cancerous glands. Visceral metastases are rarely found. The mean age is between 52 and 54 years. Phimosis seems to be a common antecedent and venereal disease was present in 28.4 per cent. The disease is undoubtedly less frequent among the circumcised. The results of local treatment of cancer of the scrotum are satisfactory; no series treated by radiotherapy is available. The only large series of cases of cancer of the vulva is that published from Radiumhemmet, where the latest method is electrocoagulation combined with radium at a distance. Of 60 cases so treated, 19 were alive and well three years later.

H. J. Ullmann, M.D.

How can we Improve our Results in the Treatment of Uterine Carcinoma? Hellmut Kamniker. Wien. klin. Wchnschr., July 24, 1930, XLIII, 943.

Reviewing the results of the treatment of about five hundred cases of carcinoma of the uterus, the author concludes that irradiation alone or operation alone leads to worse results

than the combination of both. Of the operable cases, 44.7 per cent lived after five years. The vaginal operation has a primary mortality of about 7 per cent. The prophylactic roentgenotherapy after operation showed 16 per cent more cures in five years than the non-irradiated group. Early treatment of recurrences by radium and roentgen rays improves the results in these patients. Inoperable cases receive only radium and roentgen treatment, with definite benefit and some cures.

H. W. Hefke, M.D.

Distant Metastasis in Carcinoma of the Cervix of the Uterus. Frances A. Ford. Minnesota Med., July, 1930, XIII, 489.

In treating carcinoma of the cervix or fundus of the uterus by irradiation, attention is usually directed to the primary site of the disease, under the assumption that distant metastasis is rare. In 564 postmortem examinations of cases in which cervical carcinoma was present, Schonberg found metastases in the liver in 13.7 per cent, lung in 4.07 per cent, in the peritoneum in 7.44 per cent, etc. In a study of twenty-four patients with uterine carcinomas, thirteen of whom had metastasis to the lungs and fourteen to the bones, a thorough study is presented. The author concludes:

"(1) Metastasis to distant regions, from carcinoma of the cervix and fundus of the uterus, occurs more frequently than is ordinarily assumed.

"(2) Pulmonary metastasis often is not accompanied by distressing symptoms, so that only by frequent roentgenographic examinations is it detected in the early stages.

"(3) The presence of metastasis in bones often is overlooked because of complicating circumstances which may account for pain. Metastasis to the extremities or skull often is mistakenly attributed to inflammatory destructive lesions.

"(4) Some relief of pain may be secured by effective irradiation of metastatic growths in bone from carcinoma of the uterus. This response seems less definite and less prolonged than that obtained in secondary growths from carcinoma of the breast.

"(5) There are not sufficient clinical data to warrant an opinion as to the radiosensitivity of pulmonary metastasis from uterine carcinoma. From the standpoint of greater precision in the application of radiotherapy, a fair trial of such treatment in well selected cases should be made."

W. W. Watkins, M.D.

Operation and Irradiation in Carcinoma of the Uterus. W. Weibel. Strahlentherapie, 1930, XXXVII, 302.

The author demonstrates the many difficulties presenting themselves when comparing the statistics of different clinics. Too many methods are used in treating carcinoma, and the grouping as well as the evaluation of the cases is not uniform. He pleads for the trial of one single method to be used in a number of large clinics; after ten years, it would be possible to answer the question as to the comparative efficacy of operation and irradiation and irradiation alone.

In his own clinic, the author is still operating on all operable cases by carrying out either the abdominal or vaginal hysterectomy. Following operation, all patients are subjected to roentgen treatment in spite of the absence of recurrence, continuing once or twice for several years. All inoperable cases are treated by X-rays and radium combined. In carcinoma of the fundus, operation is the method of choice.

Ernst A. Pohle, M.D., Ph.D.

The Single Massive Dose in the Treatment of Carcinoma. G. Miescher. Strahlentherapie, 1930, XXXVII, 17.

The Fractional Dose Method. Hans R. Schinz. Strahlentherapie, 1930, XXXVII, 31.

Miescher demonstrates in this report his experience with the single massive dose method in the treatment of skin carcinoma. It appeared that both basal and squamous cell carcinomas respond to a single exposure only if

a certain minimum dose is given, which lies in the neighborhood of from 1,200 r to 1,500 r. According to the depth of the lesion, filters of from 0.5 mm. to 1.0 mm. Al or Zn were used. Eighty-nine per cent of the basal and 75 per cent of the squamous cell carcinomas were cured with one single treatment; additional therapy increased these figures to 94.5 per cent and 80.4 per cent, respectively. Tables demonstrate the results in detail. The limitation for the applicability of the massive dose method lies in the tolerance of the tissue. Even from 1,200 r to 1,500 r, given over a large field, leads to reactions which may easily become serious. The same reasoning renders the use of this method unsuitable for use in other organs than the skin.

Schinz outlines a method of roentgen therapy in the treatment of malignant tumors which has been developed recently in his clinic. It intends to imitate the effect of radium by using protracted fractional doses. The involved area is irradiated once or twice daily, applying one-third E.D. in from one to two hours' treatment time. The filter is from 1 mm. to 3 mm. Cu. the F.S.D. 60 cm. to 100 cm.; fourteen exposures are given in about sixteen days. The skin reaction is similar to the radio-epidermitis described by French authors.

Histological studies have brought out the act that the connective tissue is not much injured by this method of application, in spite of the high total dose administered. A number of cases are reported in which this procedure has been used to advantage.

While no final conclusions are possible at the present time, Schinz feels that the protracted fractional dose method appears to be promising in the treatment of malignant disease.

ERNST A. POHLE. M.D., PH.D.

Primary Carcinoma of the Maxillary Antrum. Charles E. Stone. Jour. Indiana St. Med. Assn., July, 1930, XXIII, 315.

So far it has been impossible to apply primary radiation to neoplastic growths in the maxillary antrum. It is essential that all the malignant tissue should be removed surgically, depending on subsequent radiation to clean up whatever may have escaped the surgeon. The practice at different clinics varies, but the value of radium in supplementing the efforts of the surgeon admits of no question. At the Mayo Clinic the tumor is destroyed by slow heat, with soldering iron, after which radium is introduced directly into the antrum, either immediately or from ten days to two weeks later.

W. W. WATKINS, M.D.

The Choice of the Treatment Method in Carcinoma of the Cervix, Based on Clinical and Pathologic-anatomical Classification. S. Recasens. Strahlentherapie, 1930, XXXVII, 266.

Recasens, who holds the Chair of Gynecology and Obstetrics at the University of Madrid, briefly discusses the indications for operation or irradiation in carcinoma of the cervix. At present, he believes that all operable cases should be subjected to surgery following pre-operative radium treatment, since this increases the percentage of cures by 8 to 10 per cent.

ERNST A. POHLE, M.D., PH.D.

Recent Work on the Cancer Problem. Joseph C. Bloodgood. West Virginia Med. Jour., July, 1930, XXVI, 410.

This is a review of the work now in progress in European cancer laboratories, based on a recent tour of Europe. Work on the cause of cancer is still being conducted along the line of carcinogenic agents by Ernest L. Kennaway in London. The work of Otto Warburg on the metabolism of tumor cells has aroused considerable interest and controversy. No experimental support has been given the theory that cancer begins as a general systemic disease. Nothing new has been added to the diagnosis of malignancy in general, although investigation into serum diagnosis is still being conducted. Biopsy and the use of the frozen section is not as widespread in Europe as in America. At the Cancer Hos-

pital in London, as at Johns Hopkins, search for a differential cancer stain is being conducted. Investigation for cancer cure is widespread. Radium has had a distinct rise in popularity in Europe, as well as in America. Treatment by colloidal lead has been abandoned. Attempts to immunize against cancer are being tried in Germany and in England.

W. W. WATKINS, M.D.

Should the Operable Carcinoma of the Cervix be Treated by Surgery or by Irradiation? R. Hubert. Strahlentherapie, 1930, XXXVII, 334.

Between 1920 and 1929, 397 cases of carcinoma of the cervix were admitted to the author's clinic. Indications for the proper treatment were decided by one man, namely, the head of the clinic. Thirty-eight per cent of the patients were found operable; in 103 cases the radical operation of Wertheim was carried out. The primary mortality amounted to 12.6 per cent. Since some types of carcinoma of the cervix are refractory to irradiation, all operable cases were treated by surgery. In the presence of extragenital complications, for instance, heart lesions, radiation therapy is to be given the preference. Young carcinoma patients, cases of adenocarcinoma, and patients in poor financial circumstances are operated on, as a rule, even if the risk of operation is higher than usual. This social indication for operation is explained by the fact that the patients in poor circumstances do not return regularly for the required series of treatments.

ERNST A. POHLE, M.D., PH.D.

Utilization of Immunity in Treatment of Cancer. J. C. Mottram. The Lancet, May 3, 1930, CCXVIII, No. 5,566, p. 961.

As the treatment of cancer by removing some of the tissue, irradiating it, and re-injecting it into the patient in order to produce an immunity, has been advocated and carried out on patients, the author thought it desirable to try this treatment experimentally on tumors produced by tar in mice. He quotes Woglom's review of the literature in the introduction to the paper to show that all treatments of patients, based on experiments with inoculated cancer, are open to the criticism that human conditions are not reproduced in inoculated cancer, but as it is possible to carry out experiments with spontaneous tumors in animals, as the author has done, trials of this method on patients are not justifiable until the animal experimentation has been finished and the method shown effective. The experiments tried were entirely negative. There was no influence on the growth of these spontaneous tumors after inoculation of sections of the irradiated tumor. Therefore, the author concludes that the results obtained with inoculated cancer do not justify the treatment of cancer patients in a similar manner.

H. J. ULLMANN, M.D.

Cancer of the Breast. Moses Behrend. Med. Times, July, 1930, LVIII, 214.

A lump found anywhere in the breast should always be removed. Before any operative procedure, the patient should be given X-ray therapy and radiographs made of the lungs and long bones if there is any suspicion of them. X-ray treatment should always be used after operation for malignant tumors of the breast.

W. W. WATKINS, M.D.

On the Results of Radiation Treatment in Inoperable Carcinoma of the Cervix. Walther Schmitt. Strahlentherapie, 1930, XXXVII, 322.

In the author's clinic, 163 inoperable carcinomas of the cervix were irradiated between 1913 and 1923. Seventy-seven women were treated with radium, and eight of these, or 10.4 per cent, were still well after five years. Seventy-two women were treated by radium and X-rays, and six of these, or 8.3 per cent, were still alive after five years. Fourteen women were treated by X-rays alone, and none of them survived after five years. The percentage of cures in the entire group was, therefore, 8.58 per cent.

During the same period 120 cases of carcinoma of the cervix were treated by surgery. Forty-eight of these patients remained well after five years, corresponding to 40 per cent. The total number of cases. operable as well as inoperable, during that period amounted to 305 patients. 20.3 per cent of whom were cured by operation or irradiation. This is the absolute percentage of cures based on all cases without deductions.

ERNST A. POHLE. M.D., PH.D.

Lesions Originating in the Mucous Membrane of the Mouth. C. J. Broeman. West Virginia Med. Jour., June, 1930, XXVI, 339.

Were it not for the fact that so many lesions in the mouth are likely to become malignant when neglected, the care and diagnosis of these lesions would not be of such vital importance. The author discusses a great variety of lesions found in the mouth. and the necessity for careful diagnosis. In epithelioma of the mucous membrane of the mouth radium is the treatment of choice, with cautery or diathermy used in conjunction; the adjacent glands should be irradiated. For epulis. radium. surgical diathermy. or cautery may be used. Carcinoma of the tongue should be treated with radium. All forms of treatment should cause as little destruction as possible. and should, preferably, consist of a single application rather than a series of applications.

W. W. WATKINS. M.D.

The Results of the Treatment of Uterine Carcinoma from 1918 to 1930. Rud. Th. v. Jaschke. Strahlentherapie, 1930, XXXVII, 293.

Between 1918 and 1930, 318 cases of carcinoma of the uterus (223 in the cervix and 75 in the fundus) were treated in the author's clinic. Of the 223 cases of carcinoma of the cervix. 64.5 per cent were operable (140 women were operated on). Only 130 cases could be observed for five years or longer. In these 130 patients. the operability was 58.4 per cent; 32 were cured. corresponding to an absolute permanent cure of 23.8 per cent. Seventy-five of the 130 patients had been observed more than five years, and of these, 25, or 33 per cent, are still well. Forty per cent of the total number of patients were admitted to the clinic in a condition which rendered the prognosis almost hopeless. The author operated on every case possible, followed by X-ray deep therapy to the pelvis.

Eighty-three cases were treated by irradiation alone; 55 of these could be observed more than five years. Five of the 55 patients, or 9 per cent, are still well. This poor result of radiation therapy is explained by two facts: one is that all operable cases went to the surgeon, and the other is the lack of co-operation of the patient. The women whose condition was improved following the first application of radium did not return for the next treatment. A few months later, they had to come back with a recurrence.

Of the 95 cases of carcinoma of the fundus. 67 were operated upon. 45 women being observed over five years. Twenty-three patients, or 50 per cent, are still well.

Thirteen cases were irradiated; 11 with radium; 2 with X-rays and radium. After five years, 5 are still alive. No definite conclusions are drawn, however, in view of the small number of cases.

The author emphasizes. in closing. that in order to improve the results. an organized educational campaign among the people is essential.

ERNST A. POHLE, M.D., PH.D.

Résumé of the Principles of X-ray Technic in the Treatment of Deep-seated Carcinoma. H. Coutard. Strahlentherapie, 1930, XXXVII, 50.

Coutard discusses briefly the principles of roentgen therapy in malignant disease as developed in the Curie Institute in Paris, and which are familiar to the American radiologist. He states that the protracted fractional dose method permits the application of high doses without seriously injuring blood vessels and lymphatics. As long as we do not obtain a high percentage of cures in superficial ca-

cinoma, he feels that it is futile to expect many cures by roentgen rays alone in the treatment of deep-seated malignancies. This does not exclude, however, the excellent palliative results which have been observed.

ERNST A. POHLE, M.D., PH.D.

Why and within what Limits is it Necessary to Use Inhomogeneous Irradiation in the Radium Treatment of Carcinoma? W. Lahm. Strahlentherapie, 1930, XXXVII, 79.

It is stated that the central part of the tumor or the area from which it started to grow requires much higher doses of radiation for a successful treatment than does the peripheral or younger tissue. Inhomogeneous irradiation is, therefore, indicated. This is illustrated in detail, for instance, in cases of carcinoma of the cervix.

ERNST A. POHLE, M.D., PH.D.

Combined Therapy in Malignancy. L. J. Carter. Canadian Med. Assn. Jour., June, 1930, XXII, 837.

This case report illustrates well the good results that may frequently be obtained by a combination of measures in the treatment of malignancy. The report is contributed to the *Canadian Medical Association Journal* as a part of the educative program which the radiologist should employ in spreading information concerning the possibilities of the X-ray among his confrères of the general medical profession.

The case is one of very extensive carcinoma of the alveolar margin of the left upper maxillary bone. The general condition of the patient was very poor, there being extreme cancer toxemia. Five radium needles, of 10 milligrams each, were buried in the tumor for 24 hours. Following this, a series of X-ray treatments of moderate penetration was given over the affected area and the regional lymph glands. Two months later the sloughing area was electrocoagulated and the dead bone removed, followed during the next two months by further X-ray treatments. Five months later the patient, concerning whom there had been given a most unfavorable prognosis, reported in general a good condition. He stated that some time previously the whole alveolus had come away *en masse*, leaving a clear-edged cavity. On examination this was confirmed, and no evidence of cancer could be seen. Two years later, there is no sign of recurrence, and the patient's general health is good.

THE CHEST (DIAGNOSIS)

Concerning the Roentgen Appearance of Late Congenital Syphilis. I. J. Balaban. Röntgenpraxis, Aug. 1, 1930, II, 709.

The roentgen and autopsy findings of a late congenital syphilis of the lungs are described. Two large, round, well circumscribed shadows in the lungs of a seventeen-year-old girl were diagnosed as echinococcic cysts. The autopsy findings proved them to be two gummas.

H. W. HEFKE, M.D.

Psittacosis: A Clinical and Roentgenologic Study of Seven Cases, with Postmortem Observations in One Case. Edwin Peterson, O. B. Spalding, and Otis Wildman. Jour. Am. Med. Assn., July 19, 1930, XCV, 171.

Seven cases were studied and roentgenologic investigation was made in all of them. X-ray films were taken daily, and the progress of the specific creeping pneumonia was carefully noted.

The characteristic features of this specific exudative mass were, first, a small, faint, circular cloud of equal density. Gradually this cloud enlarged, reaching its maximum size and density on the third or fourth day. The exudate occurred at the base of the left lower lobe in every case. The homogeneous density, contour, and location of the exudate differed from that of any pneumonic consolidation previously observed. There was an absence of the mottling of bronchopneumoni[illegible]adow was less opaque than in a typ[illegible]eu-

monia and differed in contour from a typical infarct. A characteristic feature in every case, as the disease progressed, was the migration or creeping upward of the exudate beneath the scapula, leaving normal lung tissue behind.

The tendency of the disease was to jump to the opposite base where it progressed through a characteristic cycle, appearing as a circular cloud, enlarging, increasing in density, and after the fourth or fifth day, starting to creep upward beneath the scapula, leaving clear lung tissue behind.

The roentgenologic observations were the determining factors in the early diagnosis and treatment of the disease.

CHARLES G. SUTHERLAND, M.D.

Acquired Massive Atelectasis of the Lung. Clough Turrill Burnett. Colorado Med., July, 1930, XXVII, 226.

Bradford's definition is "a collapse of the lung more or less extensive, where there is no gross lesion such as fluid or air in the pleura to account for its presence." Causes may be (1) bronchial obstruction from inside the bronchus: (2) bronchial obstruction from outside the bronchus; (3) postural effects; (4) paralytic origin; (5) reflex. The clinical types may be post-operative, traumatic, or neither of these. In the X-ray examination, either a fluoroscopic examination or two roentgenograms, one in deep inspiration and one in suspended deep expiration, will be required. The collapsed portion has a density as great as lobar pneumonia, and the mediastinal contents shift to the affected side with inspiration, and away from this side in expiration. Four case histories are given.

W. W. WATKINS, M.D.

Chest Radiography. J. G. Edwards. Med. Jour. Australia, June 21, 1930, I, 804.

After a practice extending over twenty-three years, involving the examination of over thirty thousand chest cases, the author considers that fluoroscopic examination is of little value in chest diagnosis. Opinions are based on stereoscopic films taken at from four to six feet. In abscess and hydatid disease, fluoroscopy is employed only for localization.

Eight thousand examinations of miners suspected of silicosis were made, fluoroscopy being abandoned after the first thousand cases, as affording no further information than that obtainable from the films. A well established silicosis gives an X-ray appearance somewhat similar to miliary tuberculosis, but fever is absent, unless an apical tuberculosis is superadded. A tuberculous infection advances at an extremely rapid rate in patients suffering from silicosis.

The importance of examining the nasal sinuses in cases of obscure chest disease, especially in children, is emphasized, as cough is often looked upon as being due to tuberculosis when the sinuses are infected.

J. G. STEPHENS, M.D.

Pleurolite or Free Calculus in the Pleural Cavity. Luis R. Romaguera. Tuberculosis, March, 1930, I, 340.

The author reports a case of pulmonary tuberculosis in which, after pneumothorax and phrenicotomy, a free body about the size of a pigeon's egg and of irregular outline was found in the pleural cavity. The shadow cast by it was equal in density to that of the clavicle. Macroscopically, this body was semisolid in consistency, and its shape changed with the change of position. All the theories that explain the formation of such free bodies are discussed.

M. VIAMONTE, M.D.

A Report of an Unusual Case of Hemorrhagic Disease of the Newborn. Gordon Chown. Canadian Med. Assn. Jour., June, 1930, XXII, 837.

An infant four days of age became ill, with difficult and labored breathing. There was definite dullness, with diminished breath sounds over the entire left chest. An X-ray report by Dr. Digby Wheeler showed the heart and great vessels to be displaced to the

right; the right half of the diaphragm normal; the left half obscured. The left chest was completely opaque, suggesting extensive effusion. The chest was aspirated and 60 c.c. of bloody fluid removed, 30 c.c. of the father's blood being given subcutaneously. The following day the effusion recurred, and 45 c.c. was aspirated and another 30 c.c. of the father's blood given. On the same day there was hemorrhage from the umbilical cord.

The case is reported because of the very unusual location of the hemorrhage, and the fact that the clotting time of the blood was normal on all occasions. The child was discharged from the hospital, cured, in ten days.

L. J. Cotton, M.D.

Tuberculous Pleurisy. Gerald B. Webb. Jour. Am. Med. Assn., July 5, 1930. XCV, 28.

"At adolescence a pleurisy will often have revealed the impregnation of tubercle and it will only be a few years later that the pulmonary localization will manifest itself. In some cases pulmonary disease will light up ten to twenty years later and subjects of pleurisy in youth may not become phthisic until mature or old age."

Tuberculous pleurisy may be acute or chronic. The acute form may be dry or accompanied by a serofibrinous or hemorrhagic fluid. Pleurisy with effusion can persist for a year or more. The condition is not infrequently bilateral. A dry pleurisy may be chronic and persist for years. Following a pleurisy with effusion the original lung focus may, by roentgen study, seem to have disappeared.

Acute tuberculous pleurisy may arise insidiously in children and adults, without pain and at times without apparent fever. In some patients utter exhaustion may precede as well as follow pleurisy. Pleuritic pain may be present when no "rub" can be detected; and on the other hand a loud pleuritic "rub" can be heard, and yet no pain may be experienced. Pain may be referred to the opposite lung. The referred pains of diaphragmatic pleurisy, which occur in the shoulder and in the abdomen, are apt to lead to diagnostic errors. With the patient on the affected side, the recumbent diaphragm at first makes an increased excursion and this intensifies the pain of diaphragmatic pleurisy. The symptoms of tuberculous pleurisy may simulate those of pulmonary tuberculosis. Digestive disturbance is most marked when pleurisy with effusion occurs on the left side.

All chest pain and pain referred to the shoulders, arms, and abdomen should suggest pleurisy. In the roentgenogram, any difference in the lighting of the two sides should be noted. From one to three years of a carefully regulated life is necessary to safeguard patients against future pulmonary disease.

Tuberculous lesions in joints and bone appear to have a value in preventing serious lung disease. Possibly an attack of tuberculous pleurisy may render the lungs more immune. Pleurisy of disease should be regarded as seriously as tuberculary hemorrhage.

[illegible] G. Sutherland, M.D.

Roentgen Localization of Intrathoracic Structures, with Report of Findings in Nineteen Cases of Lung Abscess. Clayton R. Johnson. Am. Jour. Surg., June, 1930. VIII, 1237.

The author describes a simple method whereby the dimensions and location of any structure, whether normal or pathological, may be readily calculated. The method is based on the ordinary stereoscopic roentgenograms made for diagnosis of suspected intrathoracic pathology. The technic of making the films is quite simple and consists of films made at a target-to-film distance of 180 cm., and using a vertical shift of 15 centimeters. Metal identification markers should be placed on the upper portion of each film.

The technic used for calculation embraces the following steps:

(1) On one of the films place ink dots on the rib anteriorly and the rib posteriorly at points which lie on a horizontal line with the structure for localization.

(2) Superimpose the films so that the

markers on the upper corners are exactly superimposed, and see that the right-hand edges of the films are exactly superimposed and parallel. If they are not, then draw a line marking the edge of the overlapping film.

(3) Shift the films over one another in a longitudinal direction with the right margins exactly superimposed until the shadows of the anterior rib marked in Paragraph 1 are exactly superimposed. With a needle perforate both films at the point marked in Paragraph 1.

(4) In like manner superimpose the shadows of the posterior rib and perforate both films at the point marked in Paragraph 1.

(5) *Superimpose the shadows of the* structure for localization, still keeping the right-hand borders of the films superimposed and parallel, and clip the films together.

(6) Measure the distance in millimeters between the points marked on the anterior rib. This distance multiplied ten times will be the depth of the structure as measured from the point selected on the rib. In like manner the distance may be calculated from the distance selected on the posterior rib.

(7) Measure the distance in centimeters to the right or left of the mid-sternal line if located anteriorly, and from the mid-vertebral line if located posteriorly. The plane dimensions of the structure may be measured directly from the radiograph.

For all practical purposes, an object at a maximum distance of 8 inches from the film, taken with a target film distance of 72 inches, will have a maximum distortion of 10 per cent.

HOWARD P. DOUB, M.D.

Bronchiectasis. Paul F. Whitaker. Virginia Med. Monthly, July, 1930, LVII, 233.

Bronchiectasis may be brought about intrinsically, as by chronic bronchitis, or extrinsically, as by a pleural effusion. The X-ray is of value in diagnosis. The characteristic picture in a well advanced case is extensive thickening along the course of the lung markings, which is usually seen to radiate from the hilum to the base. There may be considerable difference in the films before and after evacuation of the cavities. In early cases the diagnosis may be very difficult without injection of lipiodol. *Bronchiectasis* must first be differentiated from tuberculosis (history, localization of signs, sputum tests); *chronic bronchitis* (by lipiodol injection); *abscess of the lung* (history, X-ray appearance, diagnostic puncture); *loculated empyema*, and *pulmonary gangrene*.

W. W. WATKINS, M.D.

THE CHEST (THERAPY)

Bronchoscopic Observations in Post-operative Atelectasis: Action of Carbon Dioxide. A. Lincoln Brown. Jour. Am. Med. Assn., July 12, 1930, XCV, 100.

Bronchoscopic observations in cases of proved atelectasis can be grouped into three main types: First, those presenting the generally expected finding of a plugged bronchus; second, a group in which no plug is noted in the bronchus, but in which more or less sputum is found in the trachea or larger bronchi; third, any atypical manifestations that did not fit into the first two groups were placed in this group.

The almost pathognomonic sputum is a thick, viscid, tenacious material of such a consistency that the container may be completely inverted without the mass altering its shape or becoming detached.

An occlusion of the bronchus by an edematous swelling of the mucous membrane was observed, and suggested that atelectasis may arise from causes other than the direct plugging of a bronchus.

The action of carbon dioxide in post-operative atelectasis may be threefold:

(1) There is an increase in the rate and depth of breathing.

(2) This results in approximation of the walls of the bronchi, tending to free any secretion attached to the wall or perhaps to cause a temporary occlusion which in itself would produce violent expiratory effort and thereby tend to expel the retained secretion.

(3) Blanching of the mucous membrane

upon the administration of a moderate concentration of carbon dioxide was distinctly observed.

CHARLES G. SUTHERLAND, M.D.

Non-tuberculous Bronchopulmonary Infection, from the Internist's Point of View. R. L. Hamilton. Canadian Med. Assn. Jour., July, 1930, XXIII, 30.

One person in fifty operated upon develops some pulmonary complication. These complications comprise the following: bronchitis, suppurative pneumonitis, bronchiectasis, gangrene, or abscess. The infection may gain entrance through (1) extension by lymphatics, (2) aspiration and transplantation, (3) the blood stream, (4) trauma.

All cases should come under the co-operative study of the internist, the radiologist, and the surgical chest specialist. Medical treatment should be adopted in all cases prior to surgical interference.

The main points in the medical treatment consist of pre-operative oral hygiene (since most of the cases are the result of aspiration), rest, good food, fresh air, proportioned exercise, tonic, postural drainage, bronchoscopic drainage, lavage through the bronchoscope, vaccine, arsenic in fusospirochetal conditions, lipiodol, and pneumothorax.

L. J. CARTER, M.D.

The Prognosis of Pleurisy with Effusion. Fred W. Gaarde. Jour. Am. Med. Assn., July 26, 1930, XCV, 249.

The frequency with which pleural adhesions are found at necropsy and accidentally by roentgenologic examination would indicate that the milder form of pleurisy is common. One hundred and twenty-six cases of idiopathic pleurisy were studied to ascertain, if possible, the factors that influence prognosis.

It would seem that, if the patient survives the original acute attack of pleurisy with effusion, there is a good chance of complete recovery. If he survives the first three years, and particularly the first five years, his chances are excellent for complete recovery.

Idiopathic pleurisy with effusion should be treated as tuberculosis, rather than to allow the patient to return to work when he has recovered from the acute symptoms. The prognosis will be much more favorable.

CHARLES G. SUTHERLAND, M.D.

CONTRAST MEDIA

The Diagnosis and Treatment of Bronchiectasis with Lipiodol by the Passive Method. J. C. Gant and J. L. Harvey. Colorado Med., June, 1930, XXVII, 185.

It is important that bronchiectasis be recognized as early as possible in order to institute proper treatment. Bronchography is necessary to make an accurate diagnosis in the early stages. In order to give all suspicious cases the benefit of this method, there must be a simple technic, as many patients will not submit to more difficult procedures. Therefore a wider use of the so-called "passive method" is advocated, consisting in introducing the iodized oil into the trachea and bronchi by having the patient take it in the mouth. This method was described by A. Ochsner in the *Journal of the American Medical Association* for July 20, 1929. The throat is anesthetized until the swallowing reflex is abolished, following which the oil is taken into the mouth and the head so tilted that the oil runs back into the larynx. The swallowing reflex being abolished, the oil runs into the trachea. This is observed fluoroscopically, so that changes may be detected which the radiograph may not show.

W. W. WATKINS, M.D.

Discussion of Lipiodol in Bronchiectasis Walter C. Swann. West Virginia Med. Jour., June, 1930, XXVI, 337.

The diagnosis of bronchiectasis, in many cases, is almost impossible by physical signs alone. It may be suspected from the history, but not all patients expectorate large quantities of mucus and pus. Diagnosis of large or small amounts of bronchiectasis is so easy with lipiodol that any patient having a cough

lasting over six weeks, and not tuberculous so far as can be determined, should have lipiodol injected for diagnosis. The diagnosis after lipiodol is more certain than by any other method except bronchoscopic inspection.

The author is also convinced of its value as a therapeutic measure, having had 63.6 per cent of his cases markedly improved.

W. W. WATKINS, M.D.

Concerning the Demonstration and Treatment of Disease of Peripheral Arteries. Max Sgalitzer, Rud. Demel, Vikt. Kollert, and Heinz Ranzenhofer. Wien. Klin. Wchnschr., July 3, 1930, XLIII, 833.

Many contrast-giving substances have been used for the demonstration of arteries by injection. The author used uroselectan for this purpose in twenty cases. The artery is exposed under local anesthesia and from 10 to 20 c.c. of uroselectan are injected with a fine needle. The roentgenogram is taken towards the end of the injection. This method is of importance for the diagnosis of the exact location of obstruction or stenosis of arteries (arteriosclerosis, endarteritis, spasm, emboli, and thrombi). In a few cases of intermittent claudication and beginning gangrene of the toes, a therapeutic effect could be noticed, at least for some time.

H. W. HEFKE, M.D.

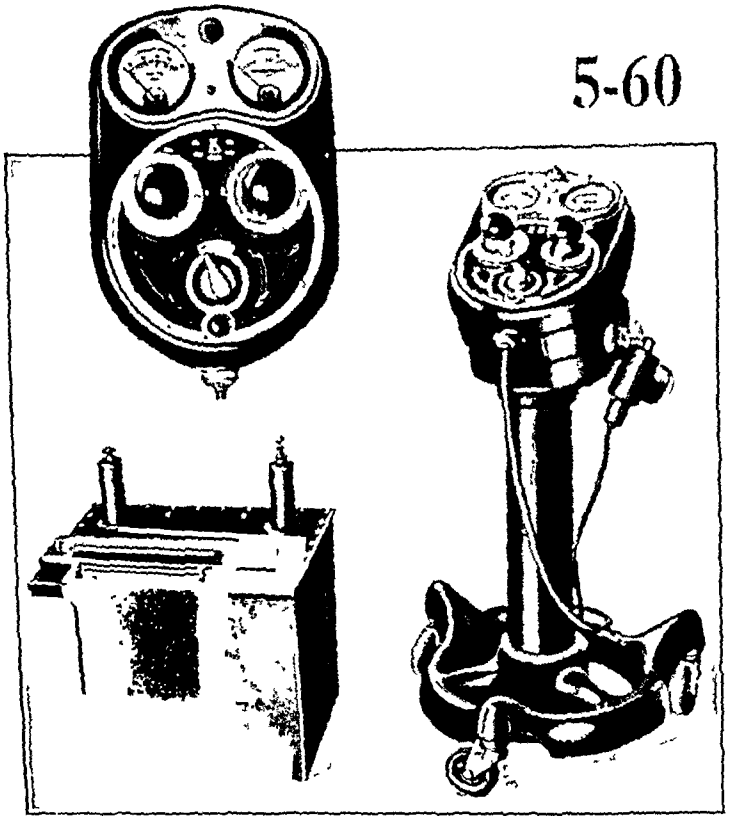
Lipiodol: Its Place in the Modern Diagnosis of Nasal Sinus Pathology. Harry Whitaker. Colorado Med., July, 1930, XXVII, 245.

Conservative treatment of the nasal sinuses requires early diagnosis. Surgery on the sinuses should not be done until after a most searching and careful diagnosis has been made. Nasal drainage and ventilation should be restored and the nose and throat observed over months before surgical treatment is considered. Lipiodol properly placed in the sinuses, properly radiated, and the films properly interpreted, adds greatly to accuracy in making a surgical diagnosis of nasal sinus disease. The author advocates the Proetz displacement method, with films in various positions and at varying periods after filling of the sinuses. In this method all the cells which can be filled, will fill, and when filled show with what readiness they can be emptied. This indicates the line of treatment.

W. W. WATKINS, M.D.

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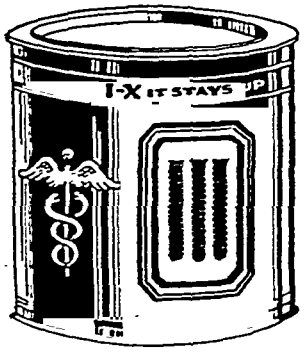
Another wrote, "This is rather late to tell you how well pleased we were with the fine lay-out and management of the Commercial Exhibits at the Toronto convention, but even so, it is no more than living up to the records you have established in the past."

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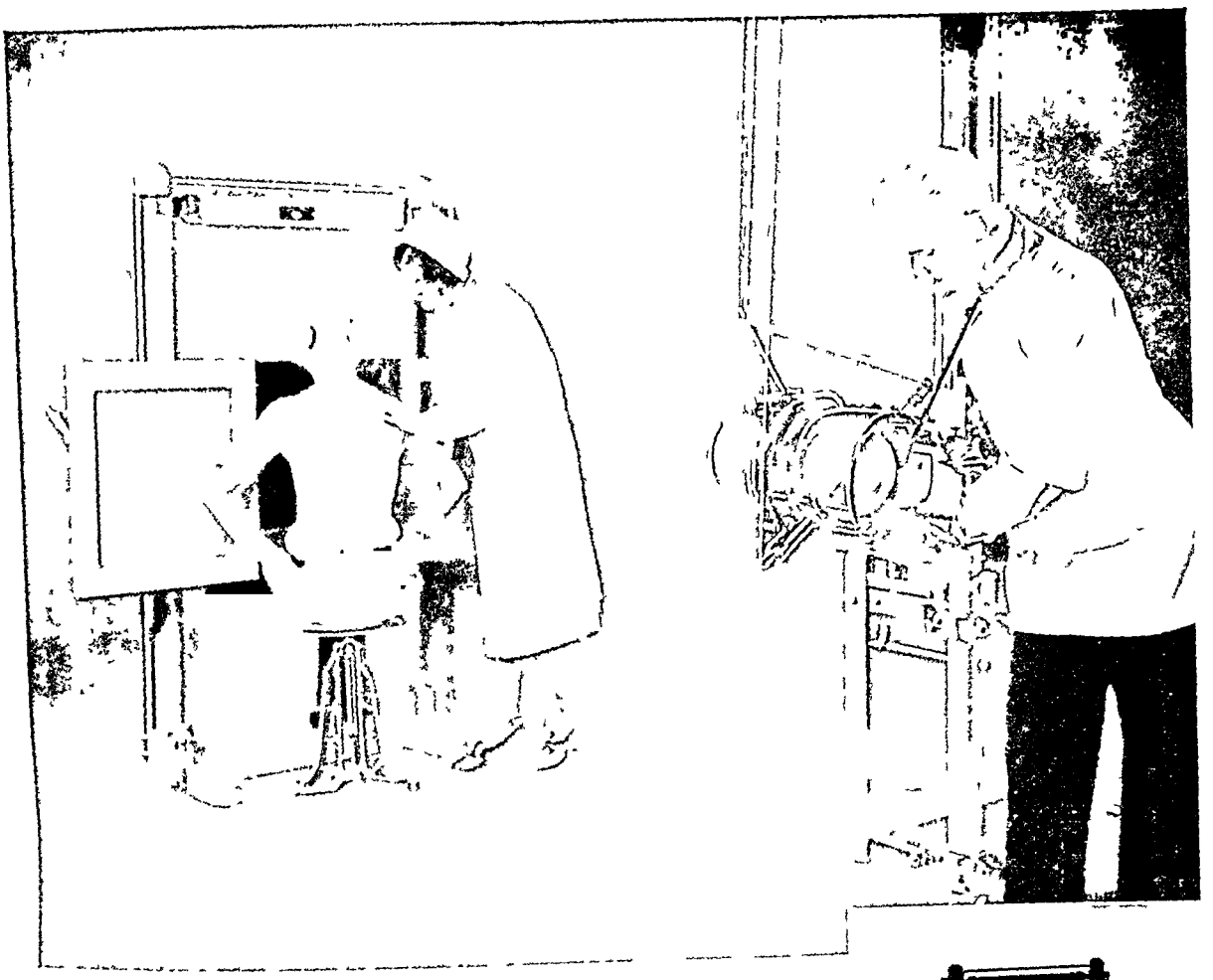
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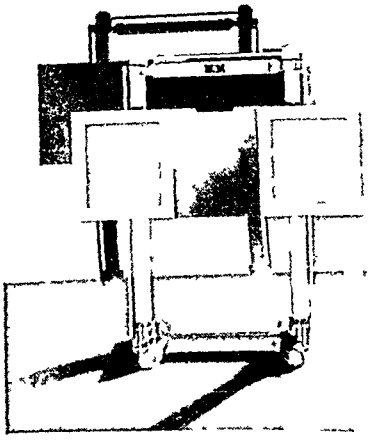
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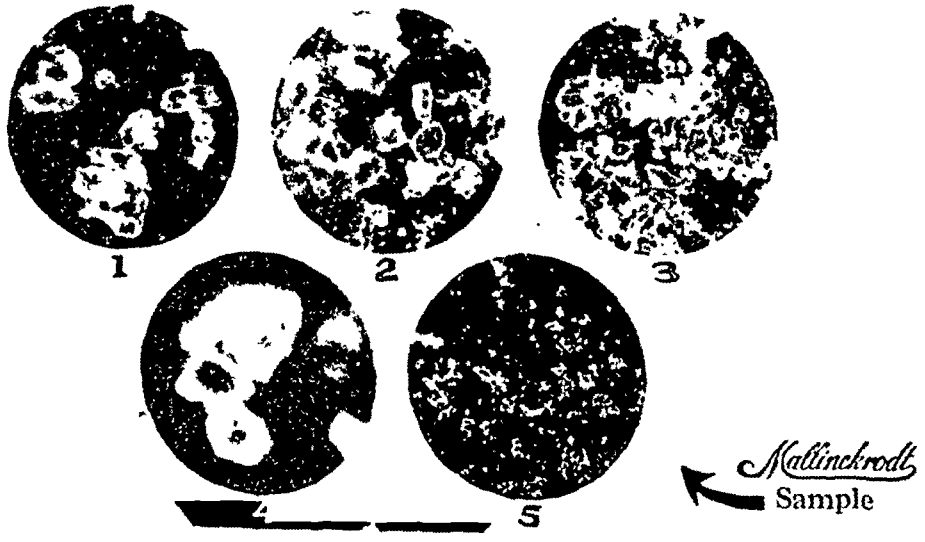
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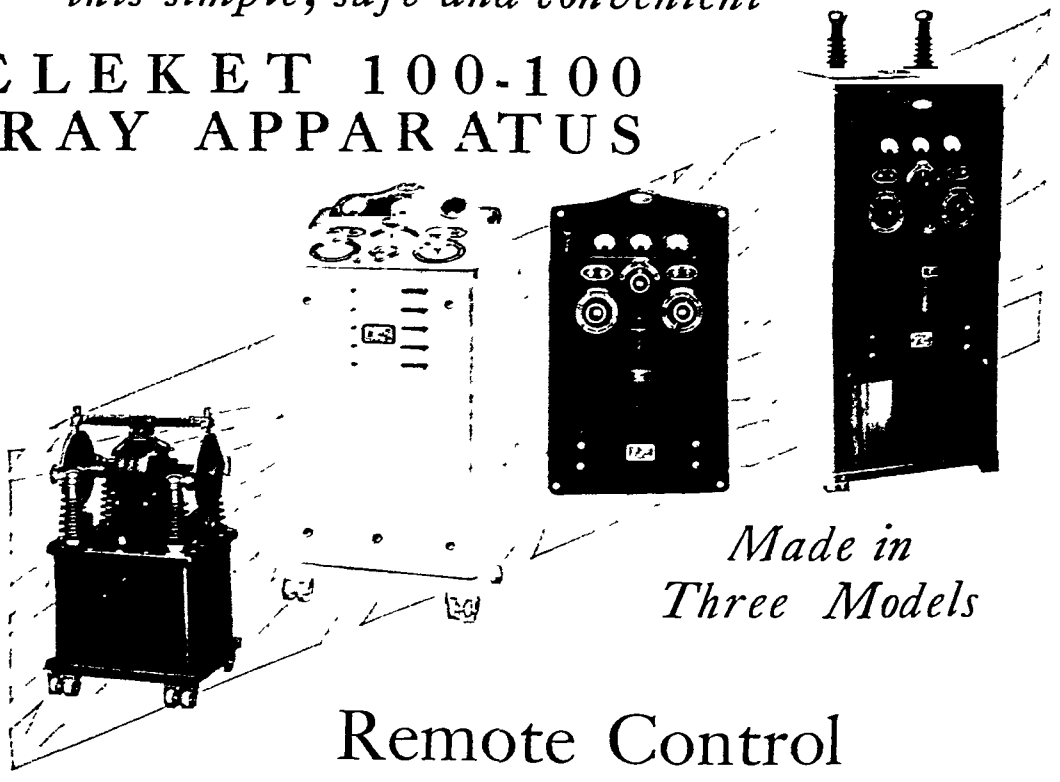
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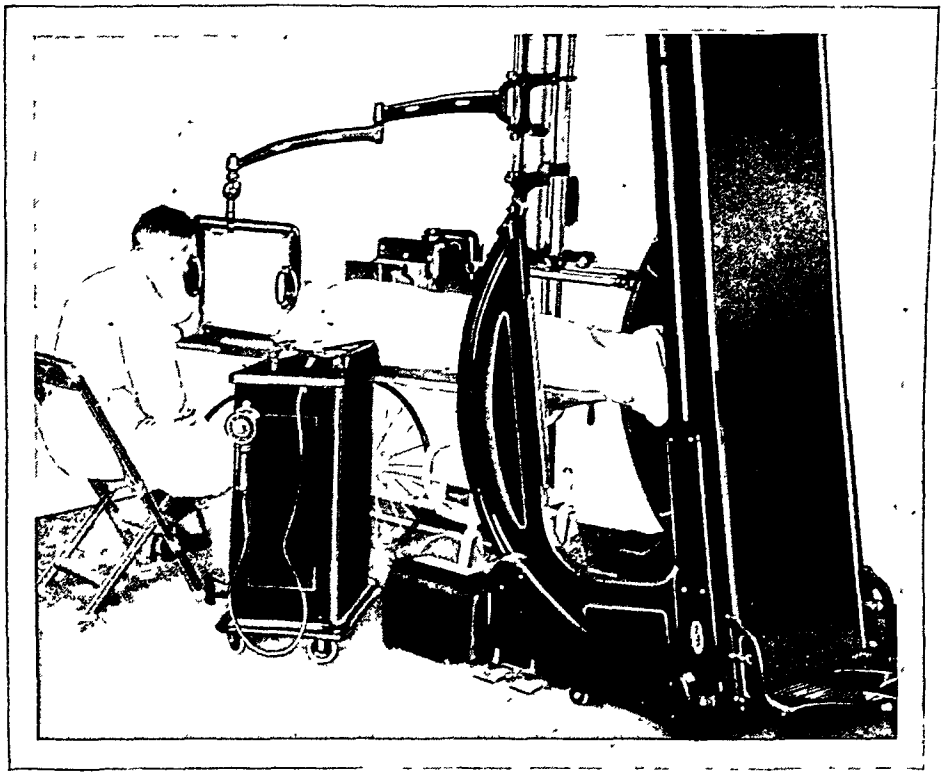
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THE SITE OF PREDILECTION IN CROSS-INFECTION FROM THE RIGHT TO THE LEFT LUNG[1]

By THE COLE COLLABORATORS, LEWIS GREGORY COLE, M.D., RUSSELL WRIGHT MORSE, M.D., ROBERT EARL POUND, M.D., COURTENAY I. HEADLAND, M.D., and WILLIAM GREGORY COLE, M.D., NEW YORK

INFECTIONS of the right lung which result in destruction of pulmonary tissue not infrequently give rise to infection in the opposite lung. This we have termed "cross-infection." It is an autogenous infection due, apparently, to the inhalation of infectious exudate and detritus (Fig. 1).

Although cross-infection of this type may occur in any part of the left lung, there is such a tendency for it to occur in a local region comprising about a fourth of the lung midway between the apex and the base, that this can be considered the site of predilection. In roentgenograms made in the usual postero-anterior projection this area lies between the second and fifth ribs. This entire area may be originally involved but usually early there will be a limited focus somewhere in this quadrant (Fig. 2).

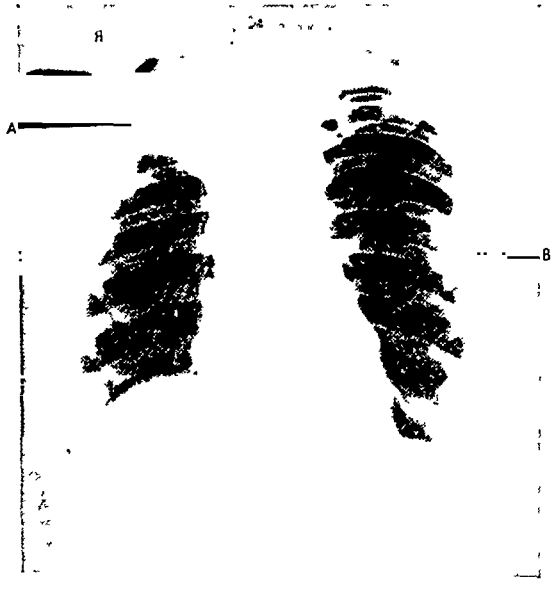


Fig. 1. Tuberculosis of right upper lobe *(A)*. Secondary cross-infection of left lung *(B)*.

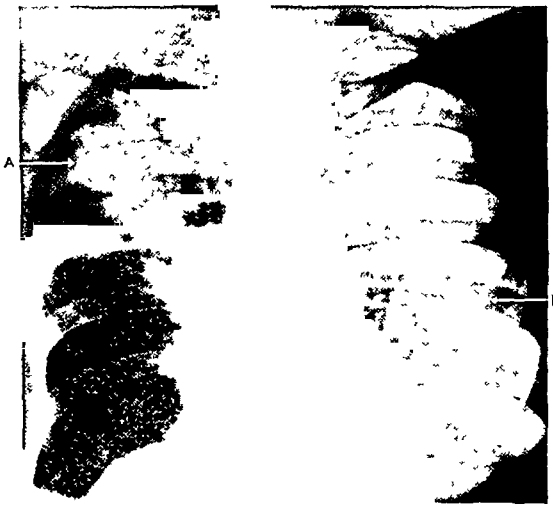


Fig. 2. Tuberculosis of right upper lobe which has resulted in cavitation *(A)*. At *(B)* there is a small area of cross-infection of the left lung.

When the destructive lesion involves particularly the right upper lobe one would ex-

[1]This paper was presented by Dr. Russell Wright Morse and Dr. William Gregory Cole at the Toronto Meeting of the Radiological Society of North America, Dec. 2 to 6, 1929.

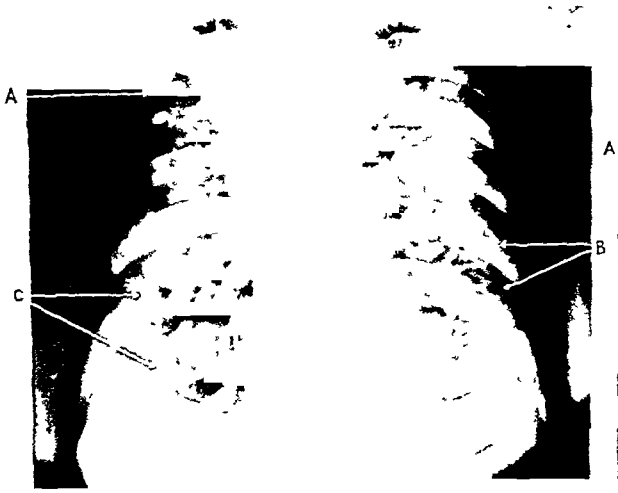


Fig. 3. Destructive tuberculosis of right upper lobe *(A)*. At *(B)* there is a diffuse cross-infection of the left lung. The involvement is largely peripheral. At *(C)* there is secondary infection of the lower part of the right lung. The involvement is mostly peribronchial.

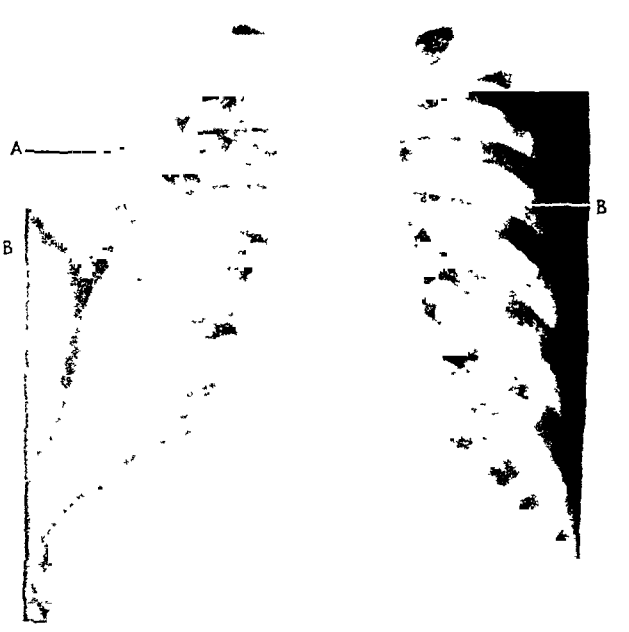


Fig. 4. Tuberculous pneumonia in right upper lobe *(A)*. Cross-infection of left lung *(B)*.

pect aspiration infection of the right lower lobe to precede cross-infection, as the bronchus to the right lower lobe is an almost direct continuation of the trachea. This type of secondary infection does occur quite frequently, usually in association with cross-infection; but the infection is largely limited to the peribronchial tissues and those alveoli adjoining the bronchi. The secondary infection in this region does not as a rule involve the peripheral parenchyma to the extent that the parenchyma is involved in cross-infection. In some cases, however, secondary infection of the lower lobe is more extensive and of greater importance than cross-infection of the left lung (Figs. 3, 4, 5, 6, and 7).

Cross-infection has been observed most frequently in the presence of a breaking down or cavitation of a caseous tuberculous lesion. This one would expect, as tuberculosis is the most common cause of pulmonary destruction (Fig. 8).

Case I.—The following case of caseous pneumonia of the right lower lobe illustrates the progressive involvement of the right upper lobe and the early involvement of the left lung by cross-infection.

4-10-29: Two weeks after an abdominal operation, there is consolidation of the right lower lobe—caseous pneumonia. There is also a diffuse infiltration in the right upper lobe. The left lung is apparently clear (Fig. 9).

4-12-29: Relatively little change is noted except a small area of infiltration at the anterior end of the second rib on the left side. This was not noticed when the films were originally studied.

4-17-29: The area of cross-infection is slightly larger. It was still unrecognized (Fig. 10).

6-3-29: There is considerable increase in the area of cross-infection, and also in the infiltration of the right upper lobe (Fig. 11).

7-11-29: Extensive involvement of the left lung and the right upper lobe (Fig. 12).

Case II.—This case illustrates the progressive involvement in a fatal case of pneumonic tuberculosis. The patient was a 15-year-old Negress, admitted to the Fifth



Fig 5. Sept. 13, 1929. Bronchopneumonic type of tuberculosis of right upper lobe. Notice that at this time there is no infection of the lower or middle lobes of the right lung and no cross-infection of the left lung. Within ten days caseation necrosis resulted, with cross-infection of the left lung and involvement of the lower part of the right lung. (See Fig. 6.)



Fig. 6. Sept. 23, 1929. Same case as shown in Figure 5. At this time there is excavation in the right upper lobe *(A)*, cross-infection in the left lung *(B)*, and secondary infection *(C)*. In this case the secondary infection of the lower part of the right lung is more extensive than the cross-infection.

Avenue Hospital as a case of pulmonary abscess.

2-14-24: Roentgenogram shows tuberculous consolidation of the right upper lobe. In the center of the consolidation there is an excavation about the size of a quarter. This does not show. The rest of the lung is normal (Fig. 13).

3-3-24: Beginning consolidation in the left lung. This was not recognized at the time of original study. There is a slight peribronchial thickening in the right lower lobe, which remains constant for quite a period of time.

3-10-24: Only at this time was the cross-infection recognized. The right upper lobe is almost completely excavated (Fig. 14).

4-24-24: There is now, for the first time, peripheral involvement of the lower part of the right lung (Fig. 15).

5-13-24: Roentgenogram made postmortem shows practically complete involvement of both lungs (Fig. 16).

It is important to note that in both these cases the presence of cross-infection was not recognized until the lesion was of considerable size, although re-examination of the roentgenograms made previously showed that it had been present for more than three weeks in the first case, and for more than a week in the second case.

Case III.—A similar cross-infection was observed in a case of pulmonary gangrene involving the lower medial part of the right lung.

8-14-29: Roentgen examination on admission to the French Hospital was made (Fig. 17). Foul expectoration. Localized pneumonia quite characteristic of abscess. There are no discernible cavities.

9-6-29: There is extensive cavitation. Bronchopneumonia in the left lung, due to cross-infection (Fig. 18).

9-24-29: The pneumonia has disappeared. The destruction in the right lung has increased and there are two well defined cavities.



Fig. 7. Caseous pneumonia of right upper lobe in which cavitation has occurred *(A)* Cross-infection of left lung *(B)* Secondary infection *(C)*. In this case also the infection of the lower part of the right lung is more extensive and conglomerate than the cross-infection.



Fig 8 Tuberculous pneumonia, with cavitation in right upper lobe *(A)* Tuberculous broncho-pneumonia (cross-infection) of left lower lobe *(B)*.

11-4-29: Roentgenogram shows healing; the former cavities have disappeared and their site is now shown only by two lines of scar tissue.

The question very naturally arises as to what the mechanical factors are which pro-

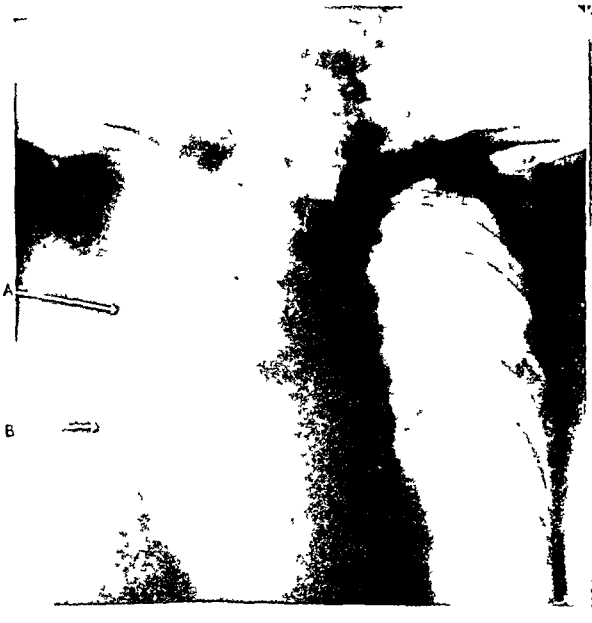


Fig. 9 Case I, April 10, 1929 Caseous pneumonia of right lower lobe *(A)* Diffuse infiltration in right upper lobe *(B)* At this time there is no cross-infection of the left lung



Fig. 10. Case I, April 17, 1929. At *(A)* there is a small area of cross-infection in the left lung. This involvement was not recognized when the films were originally studied.

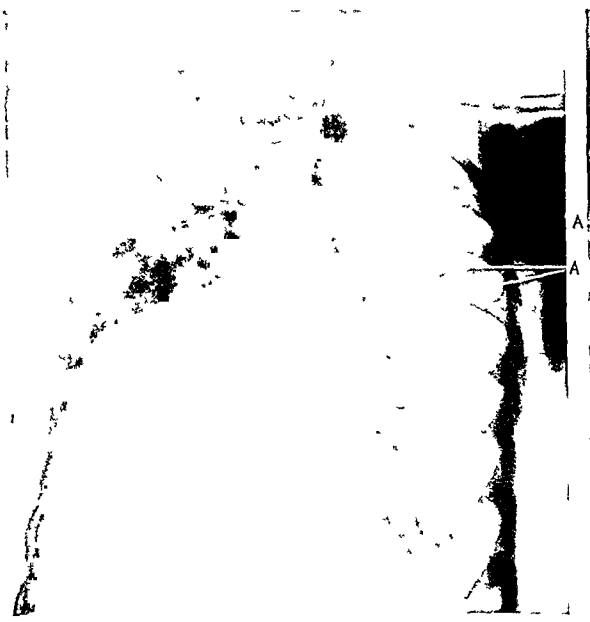


Fig. 11. Case I, June 3, 1929. At this time the area of cross-infection *(A)* was first recognized.



Fig. 12. Case I, July 11, 1929. Shows progressive involvement of the right upper lobe, with cavitation at *(A)*, and a very extensive involvement of the left lung *(B)*

duce cross-infection and make the middle of the left lung the site of predilection. This part of the lung is in continuous line with the direction of the left main bronchus. It is quite probable, therefore, that material aspirated into this region follows the path of least resistance beyond the termination of the left main bronchus. The corollary is that



Fig 13. Case II, Feb. 14, 1924. Tuberculous pneumonia of lower part of right upper lobe, with excavation at *(A)*, not shown.



Fig 14 Case II, March 10, 1924. Almost complete excavation of right upper lobe *(A)*. Extensive cross-infection of left lung *(B)*



Fig. 15. Case II, April 24, 1924. Excavation of right upper lobe *(A)* Marked increase in involvement of left lung *(B)* Peripheral involvement of the parenchyma in the right middle lobe *(C)*



Fig 16 Case II, May 13, 1924 Roentgenogram made postmortem The lungs were inflated through a rubber tube inserted in the trachea

this part of the left lung is the site of predilection because the bronchi supplying it are the most direct continuation of the left main bronchus.

This secondary lesion is usually peripherally situated and involves the parenchyma of the lungs. The infectious material must, therefore, be aspirated into the air vesicles proper. Prolonged maintenance of one posture, such as lying upon the left side during sleep, might give the opportunity for material to drain into the parenchyma of the lung. It seems more probable, however, that infectious material would collect in the bronchi and not in the air vesicles. Some added force is very likely necessary, such as is undoubtedly present in the act of coughing. The sharp inspiration which occurs after a prolonged cough or paroxysm of coughing is certainly forceful enough to drive into the parenchyma of the lungs exudate which is present in the bronchi

Case IV.—That a viscid material present in one part of the lung may be displaced into the parenchyma of this site of predilection is very conclusively shown in the following roentgenograms, which were made before and after lipiodol had been instilled into the bronchial tree. These roentgenograms are of a woman, 38 years old, who had been suffering from a chronic, severe, dry cough for the past eighteen months. X-ray examinations have been made intermittently since October, 1928.

12-8-28: Roentgenogram shows an unusual pleural and pulmonary lesion on the right side, the exact nature of which has never been determined (Fig. 19).

9-30-29: Roentgenogram shows lipiodol to be present in the lower bronchi on the right side, and a very small amount in the lower bronchi on the left side. Note that no lipiodol is present in either the middle

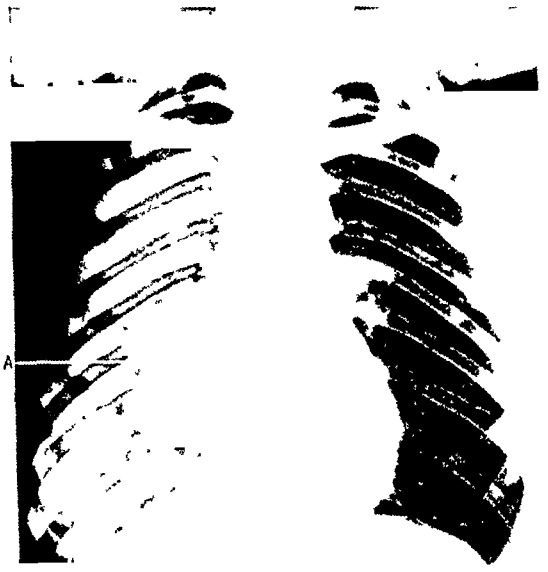


Fig. 17. Case III, August 14, 1929. Pulmonary gangrene *(A)*.



Fig. 18. Case III, Sept. 6, 1929. Cavities in gangrenous lung *(A)* Cross-infection bronchopneumonia of left lung *(B)*.

of the left lung or the bronchi leading to this region (Fig. 20).

10-4-29: Roentgenogram (Fig. 21) made five days later than that shown in Figure 20, reveals lipiodol present in the parenchyma of the left lung, in the area which is the site of predilection in cross-infection. The next figure (Fig. 22) shows this local region photographed almost to actual size. In this, one can see the granular distribution of the lipiodol, which shows even more distinctly in the original film. This granular appearance is due to the presence of the lipiodol in the air vesicles proper.

It is our belief that the frequent severe cough from which this woman suffered was the principal mechanical factor in the displacement of the lipiodol into this part of the lung.

A similar cross-implantation of infection or foreign material also occurs from the left to the right lung, and the site of predilection is relatively the same. This has not been observed as frequently, probably because these destructive types of lesion occur originally more frequently on the right than on the left side. We have not as yet had an opportunity to follow the first development of a lesion in the right lung secondary to a destructive lesion in the left lung.

In the ordinary type of subacute pulmonary tuberculosis of the adult, the apices—above the second ribs—of both upper lobes are very frequently involved. The lesions in the two lungs may be relatively of the same age and distribution, or the lesion on one side may be very apparently of longer duration and more widespread than the lesion on the opposite side.

When the lesions are of different ages it is generally impossible to determine whether the younger infection is exogenous or an example of autogenous cross-infection. The usual conception has been that these are examples of autogenous cross-infection. In all the cases of destructive pulmonary lesions which we have closely followed, cross-infection has always developed in the part of the lungs projected between the second and fourth ribs in the roentgenogram. The evi-



Fig. 19. Case IV, Dec. 8, 1928. Pleural and pulmonary lesion *(A)* of unknown etiology. Roentgenogram made before lipiodol had been injected into the bronchi.



Fig. 20. Case IV, Sept. 30, 1929. Lipiodol is present in lower bronchi on both sides. Note that no lipiodol is present in either the middle of the left lung *(A)* or the bronchi leading to this region.

dence would, therefore, indicate that cross-infection to the apex is unusual.

SUMMARY

Cross-infection from the right to the left lung is apparently quite frequent in the presence of destructive infections of the right lung.

The site of predilection within which cross-infection usually develops is in the middle of the left lung, that part of the lung which is projected between the second and fourth ribs in the roentgenogram.

Cross-infection is apparently due to the aspiration of infectious exudate and detritus present in the bronchial tree.

That viscid material from some other part of the lungs may be aspirated into the parenchyma of this site of predilection is shown by the aspiration of lipiodol in the last case (Case IV).

The site of predilection is apparently in the path of least resistance beyond the termination of the left main bronchus.

Posture of the individual may be a factor in this type of aspiration infection, but it seems probable that the sharp intake of breath following a prolonged cough or paroxysm of coughing is a more important factor in driving secretions present in the smaller bronchi into the air vesicles proper.

Estimation of prognosis in any given case of pulmonary infection does not depend entirely upon the progress or retrogression of the original areas of infection, but must take into consideration whether or not there is secondary infection of other parts of the lung.

It has been our experience in closely following the progress of a pulmonary lesion that one's attention becomes fixed upon a certain region of the lung, since one is eager to detect evidence of progression or retrogression of the pathologic process. Yet, for this very reason, the development of a secondary lesion elsewhere in the lung is very



Fig. 21 *(above)* Case IV, Oct. 4, 1929. Roentgenogram made five days later than that shown in Figure 20. At *(A)* lipiodol is present in the parenchyma of the left lung, in the area which is the site of predilection in cross-infection.

Fig. 22 *(below)* Case IV, Oct. 4, 1929. Actual size reproduction of area *(A)* in left lung shown in Figure 21. In the area noted by the arrows one can observe the granular distribution of the lipiodol, due to its presence in the air vesicles proper.

apt to be overlooked until it is of considerable size.

Knowing that destructive types of infection have a definite tendency to cross-infection and that there is a site of predilection, that part of the lung which is the site of predilection should be studied in detail in the roentgenogram in order to detect at an early stage the development of secondary infection.

SINUSES (DIAGNOSIS)

Newer Methods of Visualizing Pathology of the Nasal Sinuses. Ernest W. Carpenter. Southern Med. and Surg., June, 1930, XCII, 428.

A large majority of all secondary infections are traceable to the respiratory tract for their origin. Too often a clinical survey is made by a cursory inspection of the parts, and if no pus is found, the study is reported as negative. A simple X-ray study is of value, but in borderline cases X-ray studies of the nasal sinuses are notoriously disappointing and misleading.

The use of lipiodol is of great value in visualizing the contents and patency of the various sinuses. The author injects one antrum at a time, using a 50 per cent dilution of the oil, injecting with a straight steel needle puncturing the inferior meatus. When oil begins to drop from the anterior nares, films are made in the upright position in two planes. The following queries will usually find some answer: (1) Are the ostia patent? (2) Do the sinuses fill normally or partially? (3) Is the outline of the opaque substance in contact with the bony wall? (4) Does the sinus empty normally?

Interpretation is not always easy and must be carefully made with anatomical peculiarities in mind.

W. W. WATKINS, M.D.

The Roentgen-ray Diagnosis of Polypi of the Maxillary Antra. Howard P. Doub and Andrew R. McGee. Am. Jour. Surg., May, 1930, VIII, 1039.

The roentgen-ray examination of the maxillary antra is of particular value when searching for a hidden area of focal infection. In these cases polypi are frequently found and are disclosed either by the usual examination or by a pressure defect produced on a column of opaque medium injected into the antrum. These polypi are frequently the result of an inflammatory process of the antrum, and these, together with chronic thickening of the mucous membrane of the antrum, are undoubtedly the site of focal infection.

The introduction of lipiodol into the antra has opened up a new era in diagnosis, revealing pathology which was formerly imperfectly disclosed. A series of cases operated upon is reported, showing a very high percentage of correct diagnoses.

AN IMPROVED FORM OF STANDARD IONIZATION CHAMBER

By LAURISTON S. TAYLOR and GEORGE SINGER, WASHINGTON, D. C.

Abstract.—A modification of the open-air parallel plate ionization chamber, readily portable and adapted to field use, is described. In this chamber, narrow guard plates are supplemented by a system of ten guard wires across the ends of the chamber. The wires are so spaced that X-ray scattering from them is negligible. By this means a uniform electrostatic field between electrodes is obtained without the use of wide guard plates and the large plate-to-shield spacing necessary in the primary standard. This design has permitted a decrease in the volume and weight of the secondary standard by a factor of 15.

The results of direct comparisons between this chamber and the primary standard are given and indicate that the roentgen can be reproduced by the former with the same accuracy as the primary standard. The problem of diaphragming is identical for the two chambers, and for a given tube the same inverse power law holds for both. Like the standard chamber, the new chamber does not require that corrections be made for differences in X-ray quality.

Any of the usual electrostatic measuring systems may be used with this chamber, although for precise work a null or current compensation system is desirable.

It is expected that this type of chamber will be found useful in the international comparisons of the roentgen now pending, for which purpose the "fingerhutkammer" is generally inadequate.

I. INTRODUCTION

THE unit of quantity of an X-ray beam has been defined[1] in terms of "the ionization produced in 1 cubic centimeter of unrestricted atmospheric air"[2]; and as a result the air ionization chamber is, at least temporarily, established as the primary standard for X-ray intensity measurements.

Two distinct types of standard ionization chambers have been used: (*a*) The pressure air chamber, designed by Thaller[3] and by Behnken[4, 5] to give comparatively large ionization currents, measurable without the use of extremely sensitive instruments; (*b*) The atmospheric pressure air chamber, of which the construction and manipulation is comparatively simple. The first type was employed by the Physikalische-Technischen Reichsanstalt until their very recent adoption of a cylindrical form of atmospheric air chamber. In this country the second type has been used exclusively.

The atmospheric or open-air chamber was conceived as a result of Villard's definition of the "*e*" unit in 1908,[6] and was later developed by Friedrich.[7] As a result of further refinements by Duane,[8] Glasser,[9] Failla,[10] Küstner,[11, 12] the authors,[13, 14] and others, it is now apparently adequate for present demands. Using well-controlled, constant voltage on the X-ray tube, correct diaphragming of the X-ray beam and a refined measuring technic, the roentgen can be reproduced at the present time at the National Bureau of Standards with a mean deviation of about ± 0.5 per cent.[15]

1Second International Congress of Radiology, Stockholm, July 23 to 27, 1928.

2Paragraphs 2 and 3, "Report of International X-ray Unit Committee" (Recommended): "2. That this International Unit be the quantity of X-radiation which when the secondary electrons are fully utilized and the wall effect of the chamber is avoided, produces in 1 cubic centimeter of atmospheric air at 0° C. and 76 cm. mercury pressure such a degree of conductivity that one electrostatic unit of charge is measured at saturation current." (Recommended): "3. That the International Unit of X-radiation be called the 'Roentgen' and that it be designated by the small letter r."

3R. Thaller, O. Berg, and W. Schwerdfeger, Wissenschaftliche Veroffentlichungen aus dem Siemenskonzern, 1924, III, 162.

4H. Behnken, Zeit. fur Techn. Phys., 1924, V, 3.

5H. Behnken, Zeit. fur Techn. Phys., 1926, VII, 563.

6A. Villard, Arch. d'Elec. Med., 1908, p. 692.

7Kroenig and Friedrich, Radiation Therapy, 1922.

8W. Duane and E. Lorenz, Am. Jour. Roentgenol. and Rad. Ther., 1928, XIX, 461.

9O. Glasser and U. V. Portmann, Am. Jour. Roentgenol. and Rad. Ther., 1928, XIX, 47.

10G. Failla, Am. Jour. Roentgenol. and Rad. Ther., 1929, XXI, 47.

11H. Küstner, Phys. Ztschr., 1927, XXVIII, 797.

12H. Küstner, Strahlentherapie, 1928, XXVII, 331.

13L. S. Taylor, Bureau of Standards Journal of Research, 1929, II, 771.

14L. S. Taylor, Bureau of Standards Journal of Research. 1929, III, 807.

15L. S. Taylor, RADIOLOGY, June, 1930, XIV, 551.

It is not sufficient, however, that the unit be duplicable in any one laboratory, but there must be also good agreement between the units as determined by all standardization laboratories. In the establishment of several American and German laboratories and the Reichsanstalt. The only basis at present for agreement between the Bureau and the Reichsanstalt rests on a comparison recently made between the former and the

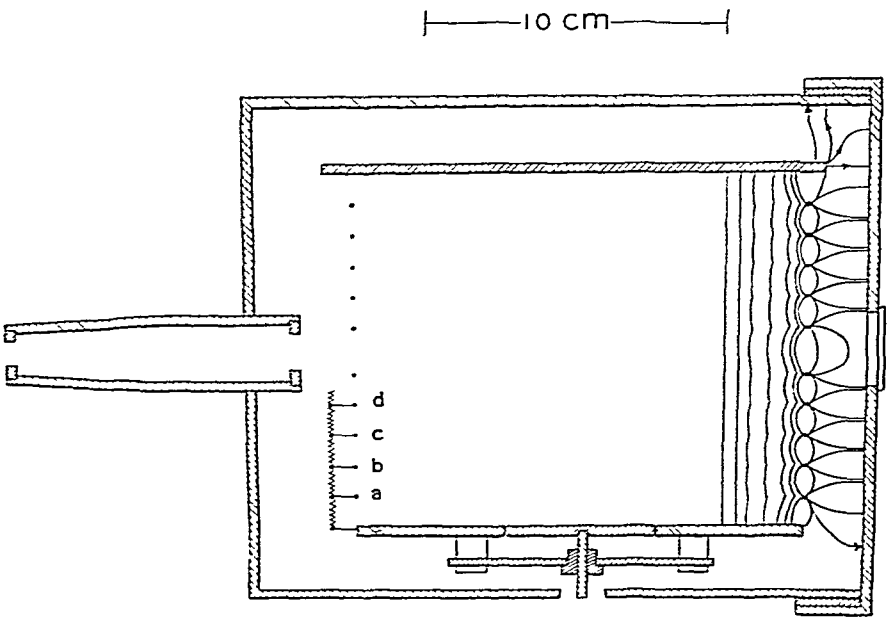


Fig. 1. Diagrammatic cross-section of ionization chamber showing some of the lines of force as affected by the guard wire system.

standards. it is obviously desirable to have them correct to one significant figure better than the magnitudes they are used to certify. Applied in the case of the international roentgen, if medical practice demands an accuracy of 5 per cent in the calibration of its ionometers. the national standardization centers should bring about an agreement, if possible. between their respective standards of 0 5 per cent. There has been as yet, however. no direct check of the roentgen between the national standardizing laboratories.

The only comparison of international character was made by Behnken[16] in 1927. before a standard was developed at the Bureau of Standards He found at the time an agreement of about =4 per cent between Cleveland Clinic which had been found to be within about 4 per cent of the Reichsanstalt.

Behnken's medium for transferring the unit was a carefully constructed ionometer with a magnesium thimble chamber and a uranium oxide auxiliary radiation standard for controlling its sensitivity. At that time this was the best known means for effecting such a comparison, but later work—particularly that of Braun and Küstner[17, 18] and this laboratory[19, 20]—has proved it to be inadequate for the high precision necessary. In a recent paper it was shown that while a thimble chamber ionometer is sufficiently ac-

16H. Behnken, Strahlentherapie, 1928, XXIX, 192.

17R. Braun and H. Küstner, Strahlentherapie, 1929, XXXII, 550.

18R. Braun and H. Küstner, Strahlentherapie, 1929, XXXII, 730.

19L. S. Taylor and G. Singer, Bureau of Standards Journal of Research (R. P. 169), 1930, IV, 631.

20L. S Taylor, Radiology, June, 1930, XIV, 551

curate for intensity measurements in X-ray therapy it is liable to errors due to such factors as the "wall effect,"[21] non-uniform distribution of ionization within the chamber, and the effective chamber length, all of which render such an instrument incapable of the precision attainable with the standard. If the various standards can not themselves be directly compared, the comparison instrument should have a precision at least as good as the standards.

With this problem of agreement in mind, at the time the present primary standard was being developed, efforts were also directed toward the design of a readily portable secondary standard, the accuracy of which would be equivalent to that of the primary.

II. CONSTRUCTION

In the design of a standard chamber, the fulfillment of certain necessary requirements renders the instrument large and heavy. For example, the plate spacing must be sufficient so that a negligible number of photo-electrons strike the plates, thus decreasing the amount of measured ionization produced by a given beam. Duane,[22] Failla,[23] and Glasser[24] found for a parallel plate ionization chamber with the beam passing centrally between the plates that a spacing of 10 cm. was sufficient. In order to permit the use of a wider beam of X-rays, the standard chamber here used has a plate spacing of 12 centimeters.

The width of the guard plates must be about one and one-half to two times the plate spacing for this type of chamber[25, 26] in order that there may be a perfectly parallel electric field across the whole width of the collector electrode. Thus, for a plate spacing of 12 cm., the guards must be about 20 cm. wide.

Also, if the plate system is to be inclosed

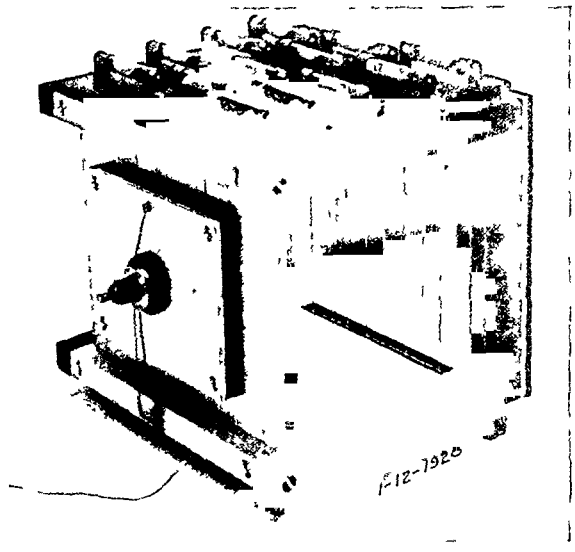


Fig. 2. Assembled electrode system showing guard wires and potential divider.

in a grounded metal box for electrostatic and X-ray shielding, the spacing between the charged plate and box must be at least that of the interplate spacing.

On account of these considerations the present standard chamber is necessarily very large and unwieldy. The cylindrical chamber used by Behnken is a little less so, but not enough to permit transportation and field use.

It has not been found possible heretofore to decrease either the interelectrode spacing or the spacing between the electrodes and the grounded case. However, by means of a guard wire system, it has been found possible for a plate spacing of 12 cm. to reduce the guard plate width from 18 to 5 cm. and, likewise, the distance between the high potential electrode and the grounded case from 12 to 3 centimeters.

This modified type of ionization chamber is shown diagrammatically in Figure 1,

21L. S. Taylor and G. Singer, see Footnote 19
22W. Duane and E. Lorenz, Am. Jour. Roentgenol. and Rad. Ther., 1928, XIX, 461.
23G. Failla, Am. Jour. Roentgenol. and Rad. Ther., 1929, XXI, 47.
24O. Glasser and U. V. Portmann, Am. Jour. Roentgenol. and Rad. Ther., 1929, XXI, 47.
25G. Failla, Am. Jour. Roentgenol. and Rad. Ther., 1929, XXI, 47.
26L. S. Taylor, Bureau of Standards Journal of Research, 1929, II, 771.

the highest precision is not demanded, an idiostatic string electrometer system is used. The nature and magnitude of the error introduced through the use of this method have been previously investigated,[30] so that

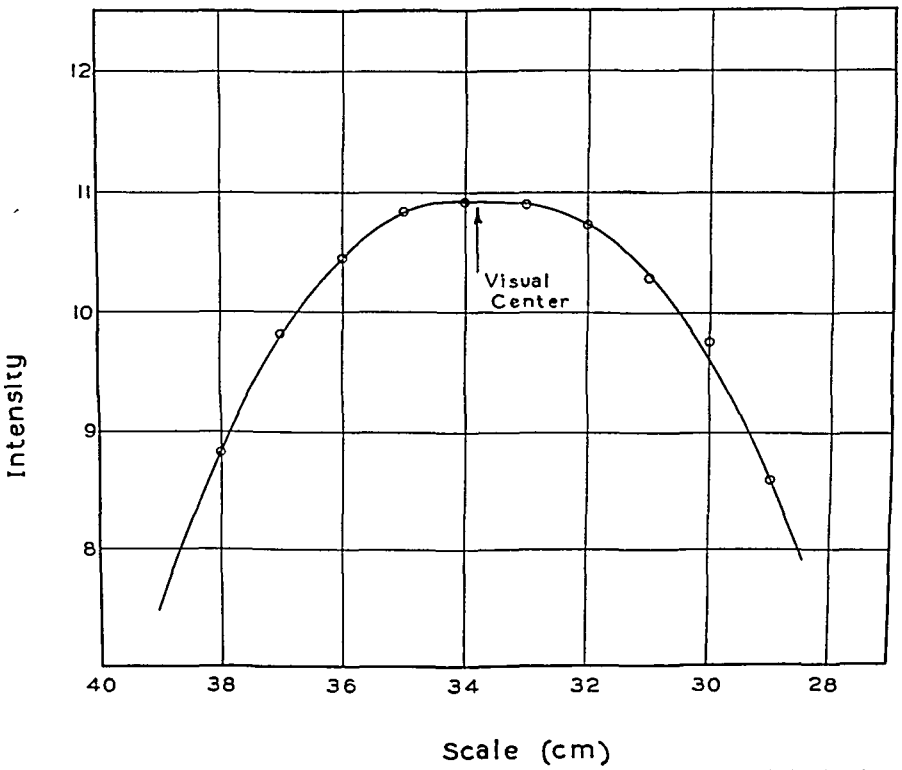


Fig. 6. Cross-section of beam to obtain lateral alignment of ionization chamber.

for the present needs the necessary correction can be made with fair exactitude. A portable idiostatic string electrometer, E (Fig. 3), is connected directly to the ionization chamber, C, by means of a flexible cable, F. A and B are concentric cylinder condensers used for changing the sensitivity of the measuring systems.[31]

The potential used to saturate the chamber is supplied from a compact portable kenotron rectifier shown in Figures 3 (H), 4, and 5. A low power 110-volt, 60-cycle transformer (R), specially built, is provided with two secondaries; S_1 to light the filament of a type H—1 kenotron K and S_2 to provide 1,550 volts rms which is rectified to give 2,200 volts direct current. In order to smooth out the rectified voltage, the capacitance, C, consisting of two 2 μf condensers in series, is inserted between the ground and the high side. A protective resistance, R, of several megohms prevents an accidental dangerous flow of current. The voltage is led to the chamber by means of a rubber-covered cable, D (Fig. 3), surrounded by a grounded copper "pigtail" sheath.

III. ADJUSTMENT AND ALIGNMENT

From the foregoing it is evident that the chamber closely resembles the standard

30 L. S. Taylor. See Footnote 20.

31 A current-balancing null system was first employed, using for this purpose a uranium oxide ionization chamber in which the ionization current was adjusted by a large iris diaphragm placed about 1 mm. from the uranium oxide covered plate. Since then Failla[32] and Jaeger[33] have devised better forms of ionization compensators; hence, it is planned in the future to use a radium-compensating chamber devised and very kindly furnished us by Dr. Failla. This system provides a wide range of currents and lends itself well to transportation, with unaltered calibration.

32 G. Failla, Radiology, October, 1930, XV, 437 (seen in MS. form).

33 R. Jaeger, Strahlentherapie, 1929, XXXIII, 542.

chamber already described.[34] This is highly desirable, since it makes the conditions of alignment and diaphragming identical for the two and consequently minimizes uncertainty due to corrections which must otherwise be made.

rely upon this method alone, particularly when used with a broad focus tube. In all cases ionization readings are made successively as the X-ray tube is shifted laterally in a direction at right-angles to the beam, and thus a measure of the intensity distribution

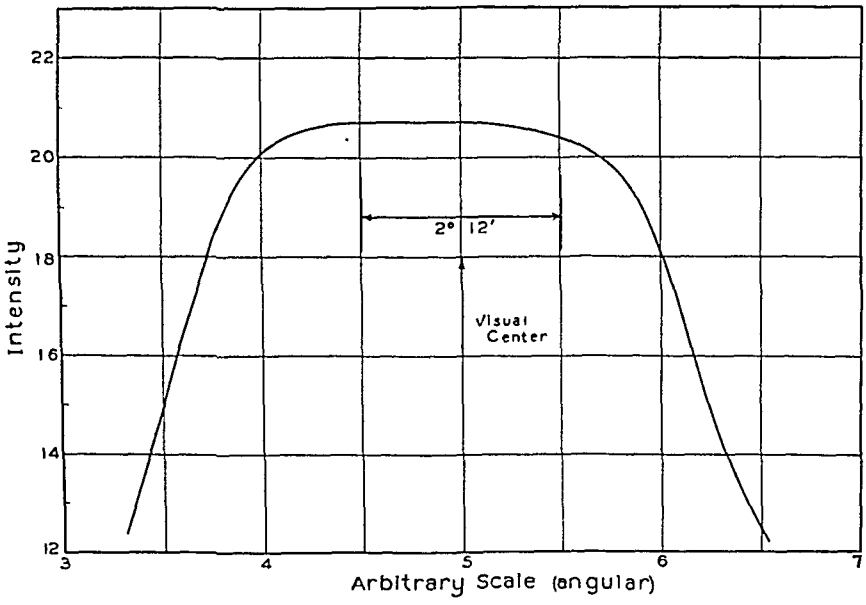


Fig. 7. Cross-section of beam to obtain angular alignment of ionization chamber.

As with the primary standard, the alignment with respect to the X-ray tube is fairly critical. For experimental test the chamber was mounted on a 2 m. track, T (Fig. 3), placed parallel to the X-ray beam and pivoted so as to rotate horizontally about its center. Lateral adjustment in the X-ray beam is effected by moving the X-ray tube. (For field use the chamber is mounted on a short track, providing the lateral motion.)

Preliminary visual alignment of the ionization chamber is made by sighting through the diaphragm system at the focal spot. This is facilitated by a cross-line marked on the celluloid window at the back of the chamber. With the small focus X-ray tube, such adjustment is fairly accurate, as shown in Figure 6, but it has been found unsafe to

[34] L. S. Taylor. See Footnotes 13 and 14.

across the beam is obtained. The final position of the chamber is that corresponding to the center of the intensity distribution peak. Likewise the chamber is tested for its angular alignment by measuring the ionization as it is rotated through a small angle about its center. Visual centering is more reliable in this case. Figure 7, showing the ionization intensity as the chamber is rotated, indicates the small range of adjustment possible; even with a fairly broad beam a rotation of over 1 degree in either direction will cause an error in the measurements.

For studying the behavior of this chamber, two X-ray tubes of the 200 K.V. Coolidge deep therapy type were employed. The first had a fine, very closely defined focal spot, while the second had a broad, poorly

defined focal spot with a "black center," these selections representing the two extremes ordinarily encountered in practice. Measurements with the standard chamber revealed a strict adherence to the inverse measurement, and *C* for a null compensation measurement. It is seen from these curves that the behavior is almost identical with that of the primary standard chamber using wide guard electrodes.[35]

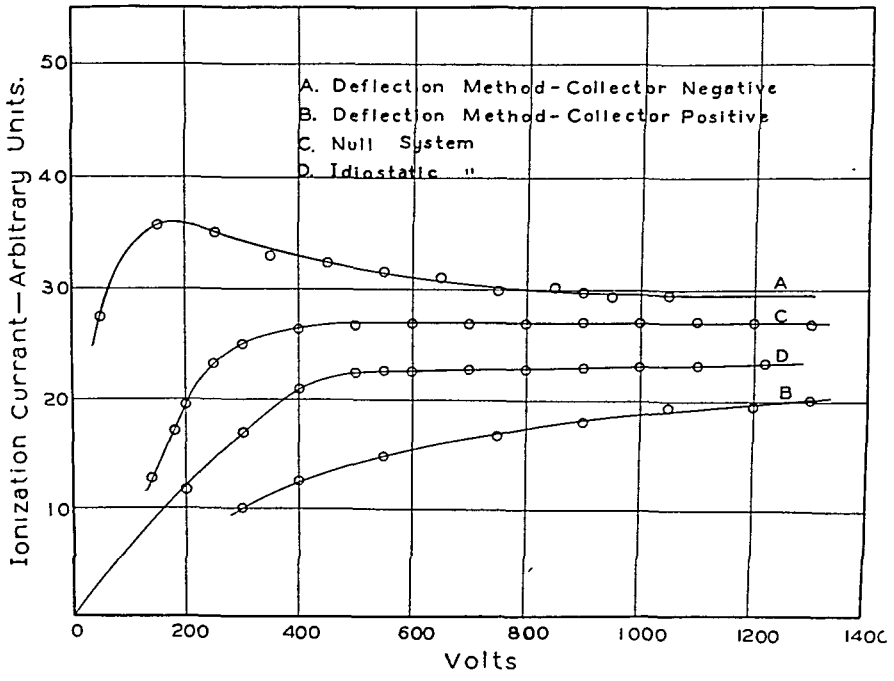


Fig. 8. Saturation curves for new ionization chamber as obtained by four methods. These are almost identical with saturation curves for the large standard chamber.

square law of intensity for the first tube and to the inverse 2.1 power for the second.

IV. PERFORMANCE

To be certain that the potential wires provided proper field correction, saturation conditions were studied as for the primary standard chamber; four different measuring methods were used, for which the saturation curves are shown in Figure 8. Curve *A* is for a system in which the collector plate is allowed to discharge to a potential below that of the guard electrodes; Curve *B* for a collector charging above the guard potential; Curve *D* for an idiostatic

The extent to which radiation was scattered from the diaphragms and potential wires was next investigated. A photographic film placed against the wires at the back of the chamber showed no shadow whatever of the wires after a long exposure with the aligned beam passing through the chamber. This indicates that scattering from the wires is negligible.

The second diaphragm used to reduce the effect of scattering from the limiting diaphragm is necessary as shown by the inverse square law curves (Fig. 9). Curve *A* shows, for the standard chamber, the logarithm of the intensity as a function of the logarithm of the distance measured between

[35] L. S. Taylor, see Footnote 13.

the focal spot of the broad focus tube and the front of the chamber diaphragm, which was set at the same diameter (0.8 cm.) as that of the secondary chamber under investigation. From the slope of this plot it is found that the intensity obeys the inverse 2.1 law. Repeating the same observations with the secondary standard, Curve *B* was obtained, showing a close parallel to the standard chamber within the experimental error. The scattering diaphragm, *S* (Fig. 1), was then removed from the back of the lead tube and, again repeating the run, Curve *C* was obtained, showing a marked divergence from the results obtained with the standard chamber. The need of the back diaphragm, *S*, is thus clearly evident.

The observations were next repeated, using the fine focus instead of the broad focus tube. Curve *D* for the primary standard chamber shows a strict adherence to the inverse square law, and likewise Curve *E* for the secondary standard—the two curves agreeing within experimental error.

The final measure of accuracy obtainable with the chamber is by a direct comparison with the primary standard chamber. To rule out any differences in the two electrometer systems for preliminary measurements, the same electrometer and compensating system was used for both chambers without necessitating any changes whatever in either the system or its connections. Both chambers were charged by the same source of high potential; in making observations, it was necessary only to shift the tube from one chamber to the other—a matter of about half a minute.

The effect of altering the size of the limiting diaphragm next to the X-ray tube was investigated, maintaining both chambers at the fixed distance of 75 cm. from the target. These data show that the two chambers fluctuate in the same manner, due to the uneven

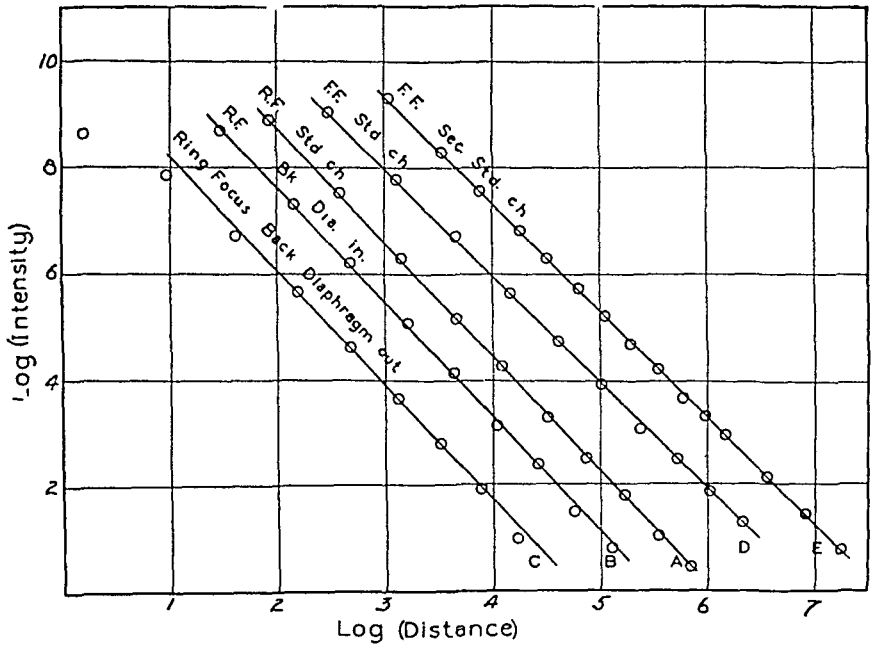


Fig. 9. Inverse square law curves for primary and secondary standard chambers. Logarithms shown are only to give slope and do not apply directly to the experimental points shown.

TABLE I

Diameter of tube diaphragm	r/min. primary standard	Deviation	r/min. small standard	Deviation	Difference
1	2	3	4	5	6
		Per cent		Per cent	Per cent
20	33.1	±0.2	32.6	±0.4	—0.7
18	32.8	.2	32.8	.1	.0
16	32.8	.3	33.0	.1	+.3
14	32.6	.2	32.6	.5	.0
12	31.6	.2	31.6	.3	.0
10	30.0	.2	30.4	.3	+.6
8	24.2	.2	24.3	.2	+.2
6	18.8	.2	18.6	.0	—.5
4	9.9	.2	9.9	.1	.0
Average difference					±.26

TABLE II

Primary standard			Secondary standard			
Tube distance	Chamber diaphragm	r/min.	Tube distance	Chamber diaphragm	r/min.	Disagreement
cm.	cm.		cm.	cm.		Per cent
94.5	0.8	14.00	94.5	0.8	14.25	±0.8
94.5	.8	5.24	94.5	.8	5.26	±.2
87.2	.8	6.23	87.2	.8	6.18	±.4

distribution of energy over the focal spot and off-focus radiation.[36]

Table I summarizes the data obtained. Column 2 gives the r/min. measured with the primary standard chamber and Column 3 the percentage mean deviation of the observations made for each point. Likewise Columns 4 and 5 give, respectively, the r/min. and the mean deviation of observations made with the secondary chamber. Column 6 shows the percentage agreement in the r/min. as measured with the two chambers, indicating that, in general, the agreement is within the observational error. All of the measurements thus far have been made with the same null electrostatic measuring system.

The final check was made using two entirely separate electrostatic current measuring systems. A few of the measurements taken under random conditions are shown in Table II, which needs no explanation.

[36] L. S. Taylor, Bureau of Standards Journal of Research, 1929, III, 807.

SKIN REACTIONS FOLLOWING EXPOSURE TO ROENTGEN RAYS

II. A STUDY OF THE EFFECT OF GRADED DOSES OF TWO DIFFERENT WAVE LENGTHS ON THE SKIN OF RATS

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IN the discussion which followed the presentation of the first paper[1] in this series (1), clinical observations were mentioned which seemed to bear out our conclusions based on the histological changes noted in the skin of rats after exposure to roentgen rays of long wave length (1–2 Ångströms). Very recently, there have appeared reports of cases which have shown late reactions such as atrophy of the skin and telangiectasis following treatment with the so-called Grenz rays (2). This fact and also the enormous variations which exist between the "erythema dose" for X-rays of long wave length[2] induced us to continue our investigations and compare the macroscopic and microscopic reactions to graded doses of ordinary roentgen rays and roentgen rays of long wave length in the skin of rats.

METHOD

Male adult rats of the same strain were used and irradiated according to the same procedure as outlined in detail in the first paper (*l.c.*, p. 499). The following two types of radiation in fields of 2 cm. × 1 cm. area on the back of the animals were employed:

(1) *Upper field.*—Seven K.V., 5 ma., 5 cm. window-to-skin distance, lambda effective 2.0 Ångströms (measured through 0.1 mm. Al), strength of the beam equal to 1.3 r per second.[3]

Apparatus.—Transformer without rectifier, Muller type tube with Lindemann window and water cooling pump.

(2) *Lower field.*—Sixty K.V., 4 ma., 20 cm. F.S.D., 2.4 r per second; lambda effective 0.6 Ångström (measured through 2.0 mm. Al).

Apparatus.—Valve tube rectifier with condenser; Metalix water-cooled therapy tube.

The doses applied were chosen as follows: 500 r, 750 r, 1,000 r, 1,250 r, 1,500 r, 2,000 r, and 2,400 r. After intervals of 7, 10, 14, 30, 60, and 90 days, the rats were killed and the skin specimens prepared for microscopic examination.

EXPERIMENTS

The macroscopic and microscopic findings will be recorded here, accompanied by a number of selected illustrations, since it is not possible to reproduce all material photographically in each group, *i.e.*, both for the same doses and for the same interval following the exposure. Two or three rats were used in each instance in order to allow for individual variations. The following report is based on a total of over eighty animals.

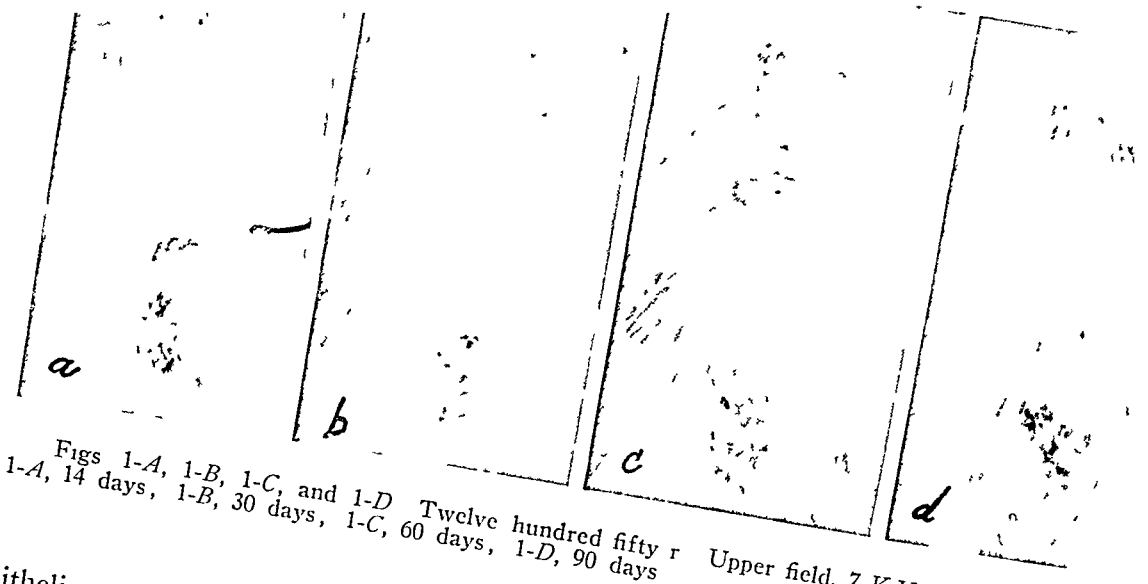
I. Exposure to 500 r (7 Days).—No macroscopic reaction. Microscopically, both lower and upper fields show very slight changes. There is some swelling of the epithelial cells and dilatation of the capillaries in the upper field.

(10 Days).—The upper field is essentially the same as at the seven-day interval. The lower field shows some thinning out of the

[1] Read before the Section on Radiology of the American Medical Association in Portland, Oregon, July, 1929.

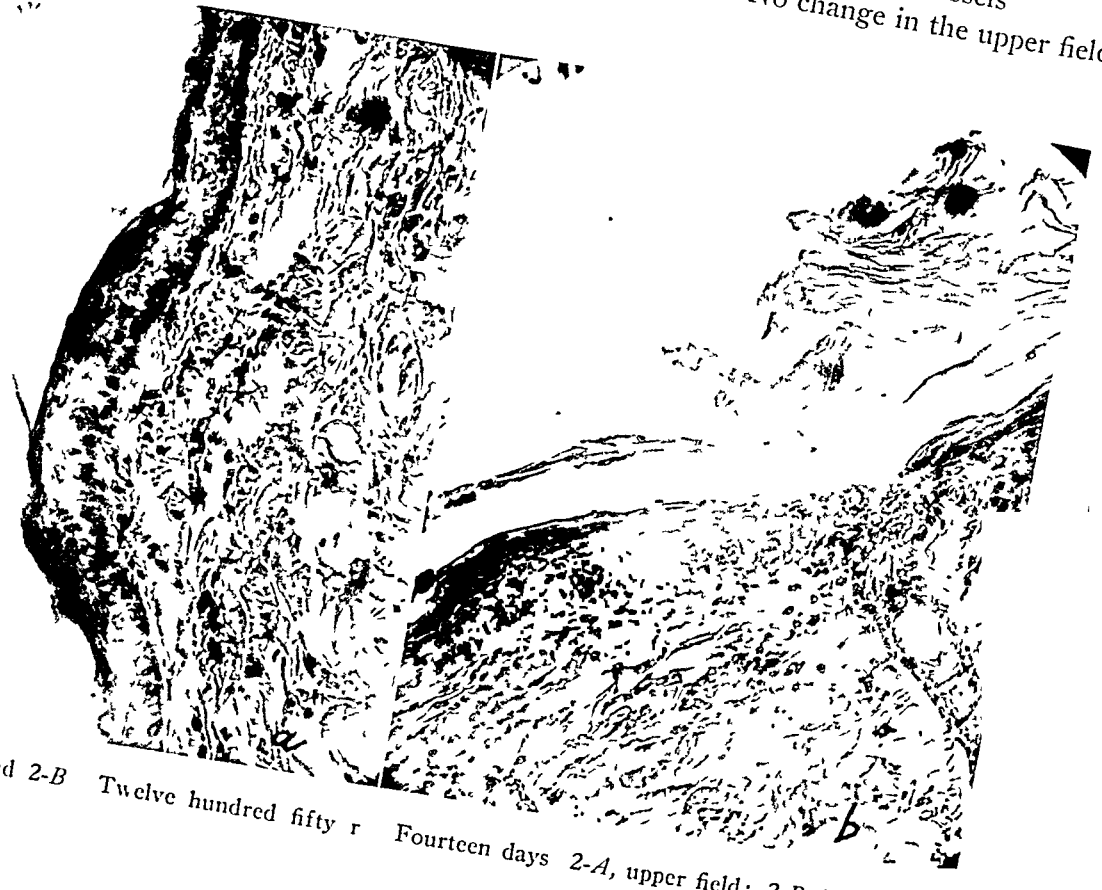
[2] According to the literature, it varies from 250 r to 1,400 r.

[3] The r-unit used here is identical with that of the Bureau of Standards, Washington, D. C.

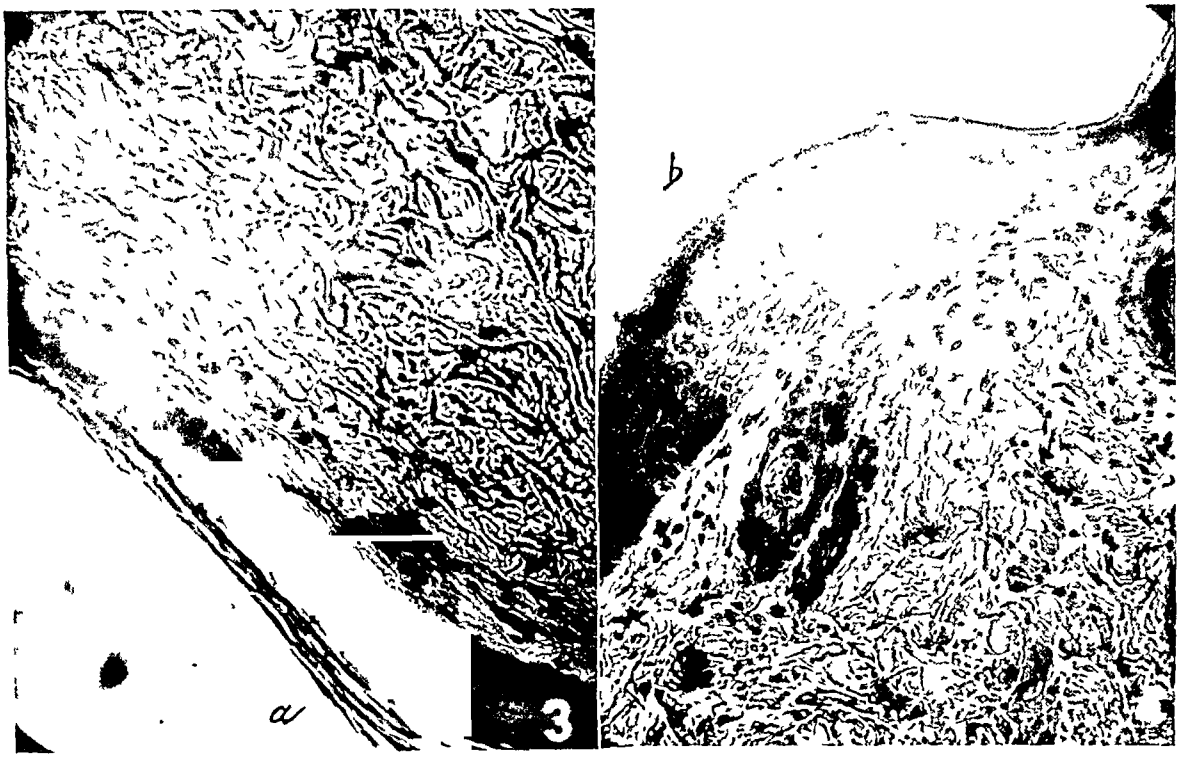


Figs 1-*A*, 1-*B*, 1-*C*, and 1-*D* Twelve hundred fifty r Upper field, 7 K V ; lower field, 60 K V
1-*A*, 14 days, 1-*B*, 30 days, 1-*C*, 60 days, 1-*D*, 90 days

epithelium and a cellular exudate in the corium, with some increase in fibroblasts *(14 Days)* —In the upper field, the deeper vessels are dilated; capillary walls swollen The lower field is essentially the same as at the ten-day interval except for a congestion of the subcutaneous vessels *(30 Days)* —No change in the upper field



igs 2-*A* and 2-*B* Twelve hundred fifty r Fourteen days 2-*A*, upper field; 2-*B*, lower field



Figs 3-*A* and 3-*B* Twelve hundred fifty r Thirty days 3-*A*, upper field, 3-*B*, lower field

except for slight thickening of capillary walls [4] In the lower field, the epithelium is thin and there is proliferation of endothelium in the capillaries

II. Exposure to 750 r (7 Days) —No macroscopic reaction. In the upper field, there is swelling and vacuolation of epithelial cells; lymphocytes and a few fibroblasts in corium. Slight swelling of capillary walls and dilatation of deeper vessels The epithelium of the lower field is thin, nuclei swollen; separation of cells; lymphocytes in corium and epithelial layer; deep vessels slightly dilated

(10 Days) —Upper and lower fields are essentially the same as at the seven-day interval.

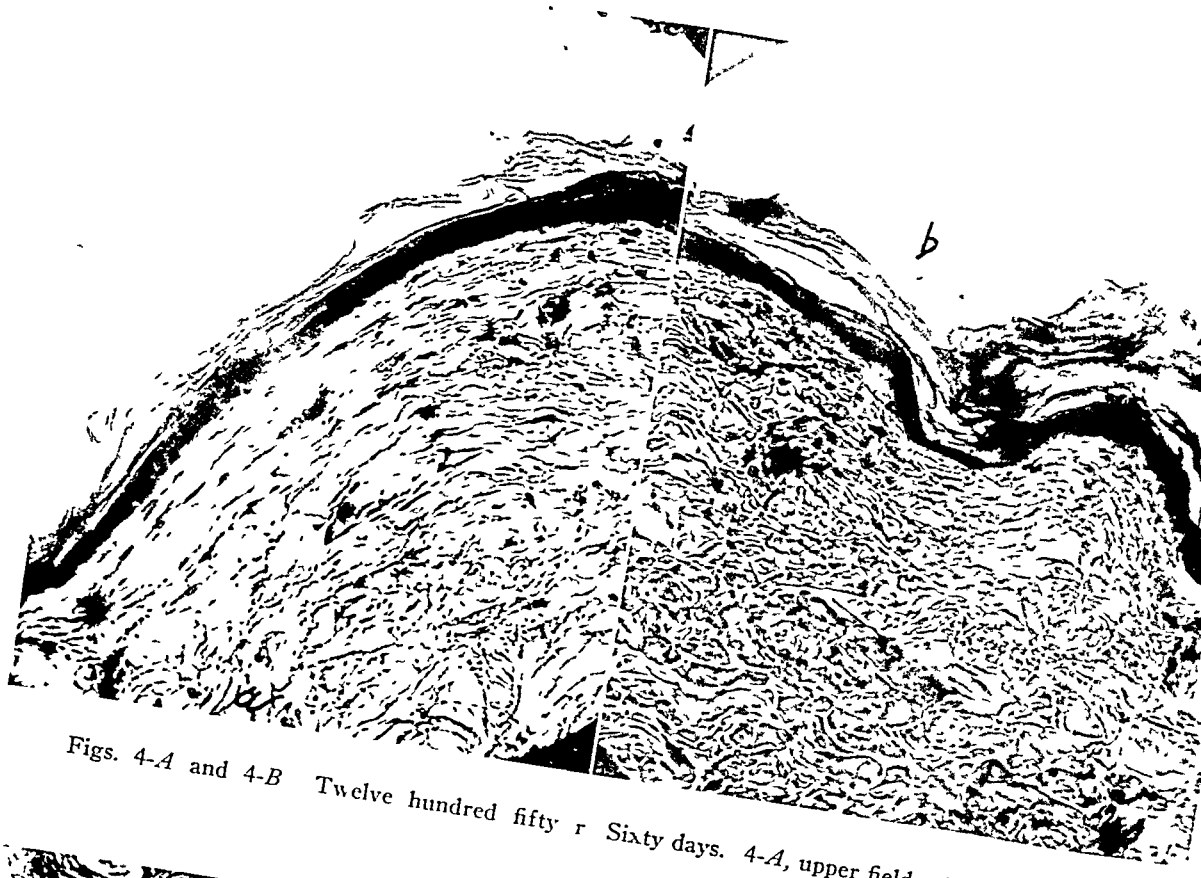
(14 Days) —In one rat, the outline of the fields appears faintly visible. In the upper field, the epithelium is thickened; lymphocytes in epithelium and corium; few fibroblasts in corium. There are slight capillary changes in the lower field; the epithelium is thin, nuclei of cells are shrunken; numerous lymphocytes in corium; congestion of deep vessels

(30 Days) —In the upper field, the epithelium is thin and shows mitotic figures, capillaries normal, few fibroblasts in corium. Epithelium in the lower field appears normal. The walls of the capillaries are thickened; few lymphocytes or fibroblasts present.

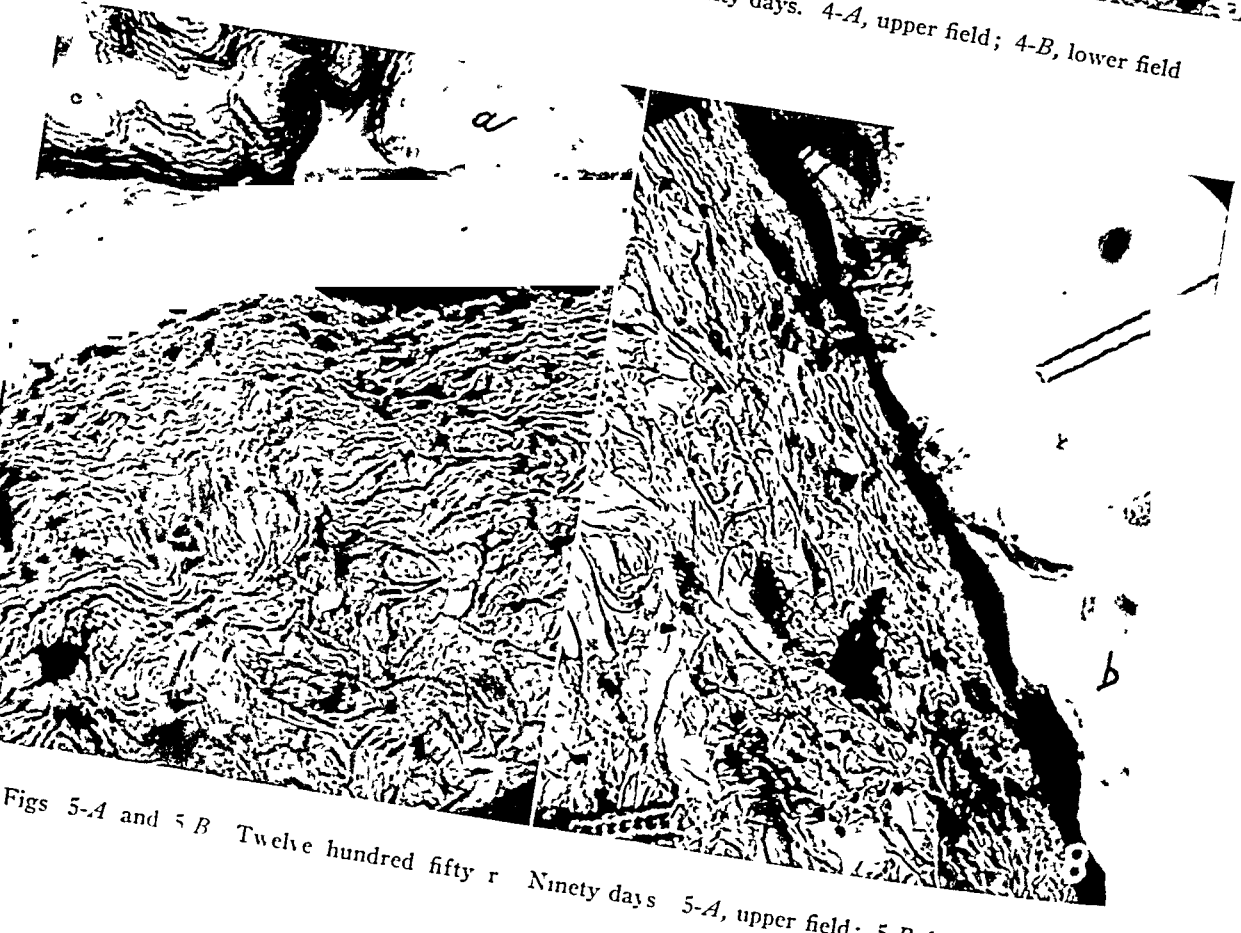
III. Exposure to 1,000 r (7 Days) —No macroscopic reaction The microscopic changes are very similar to those observed in the second group in the same interval

(10 Days) —Macroscopically, the fields begin to outline. In the upper field, there is swelling and vacuolation of epithelial cells, with lymphocytes in corium; swelling of capillary walls, with dilatation of the subcutaneous vessels. In the lower field, the

[4] The term "thickening of the capillary walls" is used to designate what appears to be a colloid swelling of the reticulum serving as a basement membrane for the endothelium



Figs. 4-*A* and 4-*B* Twelve hundred fifty r Sixty days. 4-*A*, upper field; 4-*B*, lower field



Figs 5-*A* and 5-*B* Twelve hundred fifty r Ninety days 5-*A*, upper field; 5-*B*, lower field

epithelium is thin and the nuclei of the cells are swollen. There are lymphocytes in epithelium and corium; slight dilatation of blood vessels.

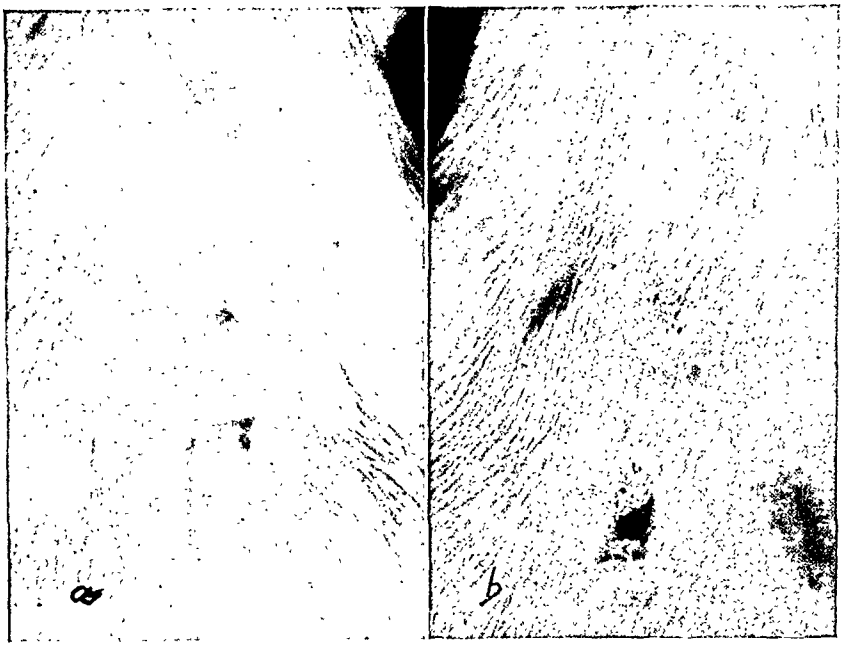
(14 Days).—Both upper and lower fields are definitely visible, with a slight preponderance of the lower area. Microscopically, there are no marked changes from the picture seen at the end of the ten-day period except for evidence of epilation in both fields.

(30 Days).—Macroscopically, both fields are still partly epilated, with fine hair growing in several areas. There is slight thickening of the epithelium in the upper field, with mitotic figures. Some lymphoid infiltration in corium and increase in fibroblasts. In the lower field, the epithelium is somewhat less thickened but shows mitotic figures; in some cases, the capillary walls are still swollen and the hair follicles are decreased in number; some hair shafts show atrophy.

IV. Exposure to 1,250 r (7 Days).—Macroscopically, both fields are faintly outlined, the upper with slightly more definiteness. Microscopically, the epithelium in the upper field is thin and, in the lower layer, the cells are separated; lymphocytic infiltration of epithelium and corium; capillary lumen small; walls thick. The changes in the lower field are essentially the same but of a lesser degree.

(10 Days).—Outline of upper and lower fields becoming more definite. Epithelium in upper field not thickened, irregular; cells vacuolated, with large nuclei; occasional hyaline necrosis of cells; lymphocytes in epithelium and corium; capillary walls thickened; hair shafts atrophic. The epithelium in the lower field is slightly thickened, with mitosis present. Otherwise, the same changes as in upper area.

(14 Days).—Both fields show desquamation, with an occasional scab within the upper field and a few erosions in the lower



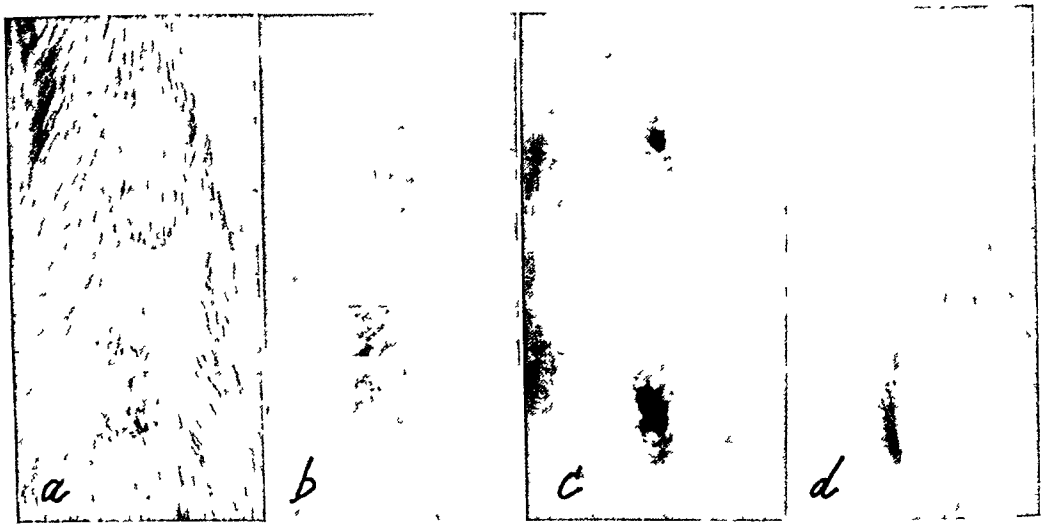
Figs. 6-*A* and 6-*B*. Fifteen hundred r. Upper field, 7 K.V.; lower field, 60 K.V. 6-*A*, 14 days; 6-*B*, 30 days.

field Epilation started (Fig. 1-*A*). Microscopically, the epithelium in the upper field is thick, with slight underlying fibroblastic proliferation; numerous lymphocytes in corium; slight thickening of capillary walls; hair shafts atrophic The lower field shows similar changes, with beginning ulceration in spots (Fig. 2).

(30 Days) —Both areas are desquamated; a small scab in the lower field; both are partially epilated (Fig. 1-*B*). There is some thickening of epithelium in the upper area, with fibroblasts and lymphocytes in corium; absence or atrophy of hair shafts. In the lower field, there is heavy epithelial growth, with atrophic hair shafts; capillary walls swollen and thick (Fig. 3).

(60 Days) —The upper area is still epilated and shows pigmentation; the lower area is of a more bluish-white color. There is fine hair growing in both fields (Fig. 1-*C*) Microscopically, the upper area shows definite evidence of a small healed ulcer, with atrophic hair follicles; capillaries swollen, thick The epithelium of the lower field is thin; no evidence of definite scar; capillaries small, walls thickened, hair shafts atrophic (Fig. 4).

(90 Days).—In both fields, the hair is regrowing; pigmentation in the upper area (Fig. 1-*D*). Microscopically, the epithelium in the upper field is thickened; lymphocytes in epithelium, with scar tissue underneath In the lower field, a thin layer of epithelium overlies a scar; capillary walls are thick; hair shafts atrophic (Fig. 5).



Figs 7-*A*, 7-*B*, 7-*C*, and 7-*D* Two thousand r Upper field, 7 K V , lower field, 60 K V 7-*A*, 10 days; 7-*B*, 14 days, 7-*C*, 30 days; 7-*D*, 90 days

V. Exposure to 1,500 r (7 Days).—The outline of the upper field is faintly visible, lower questionable Microscopically, there is swelling of the epithelium in the upper area, with mitotic figures. Lymphocytes in epithelium and corium; slight swelling of capillary walls The epithelial changes in the lower field are essentially the same; there is slight dilatation of the deep vessels

(10 Days).—A reaction is visible in both areas, more pronounced in the upper. Microscopically, the epithelium of the upper area is thin, slightly irregular, with pyknotic nuclei; some lymphocytes in epithelium In the lower field, the epithelium is atrophic; few lymphocytes in corium; deep vessels congested.

(14 Days).—Both areas are desquamated; beginning ulceration in spots in both

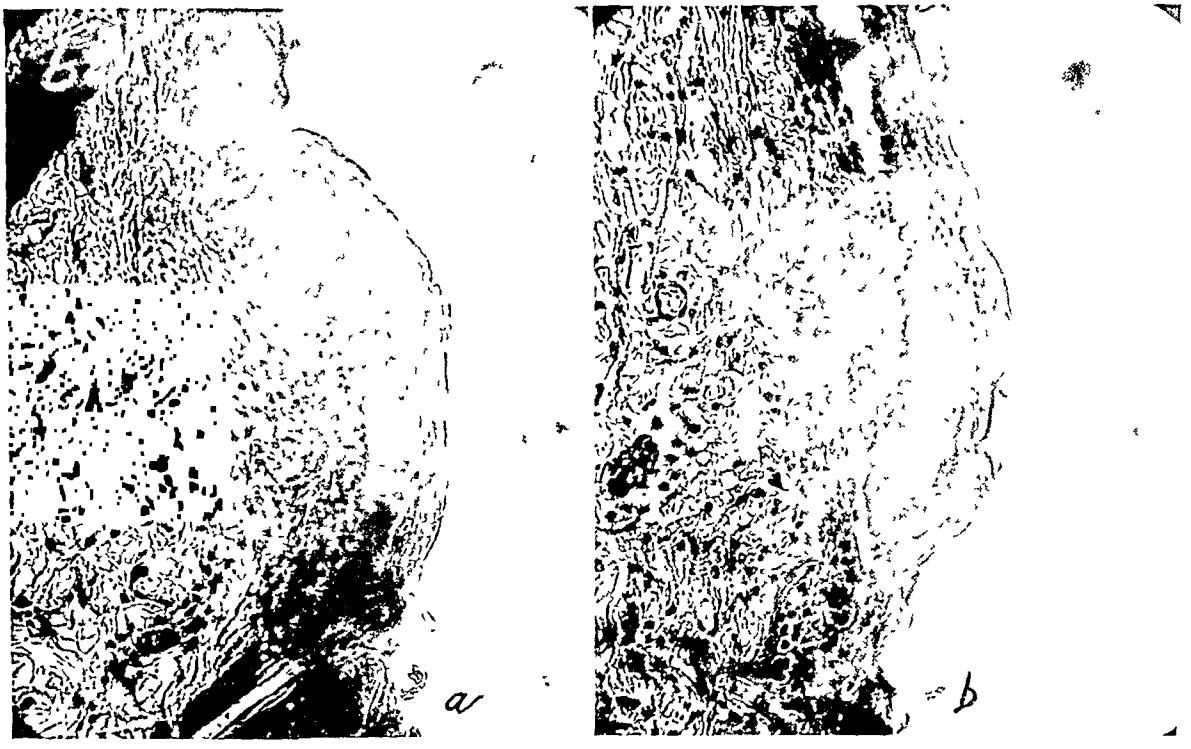
fields (Fig. 6-*A*). Microscopically, the epithelial layer in the upper field is thickened and shows numerous mitoses. There is proliferation of hair shaft epithelium; lymphocytes and fibroblasts in corium; capillaries and deep vessels much dilated. In the lower field, the epithelium is thin, somewhat irregular; cells occasionally swollen; lymphocytes in corium in groups; some endothelial proliferation of the capillaries.

(30 Days).—Both areas are epilated and show a moderate amount of desquamation. Crusts in spots in both fields, more in the lower (Fig. 6-*B*). In the upper area, the epithelium is thickened, irregular, with mitosis and invasion by lymphocytes, fibroblasts, and eosinophiles in corium; capillaries dilated; walls thin; hair shafts almost absent; some proliferation in few remaining shafts. The microscopic picture of the lower field is very similar.

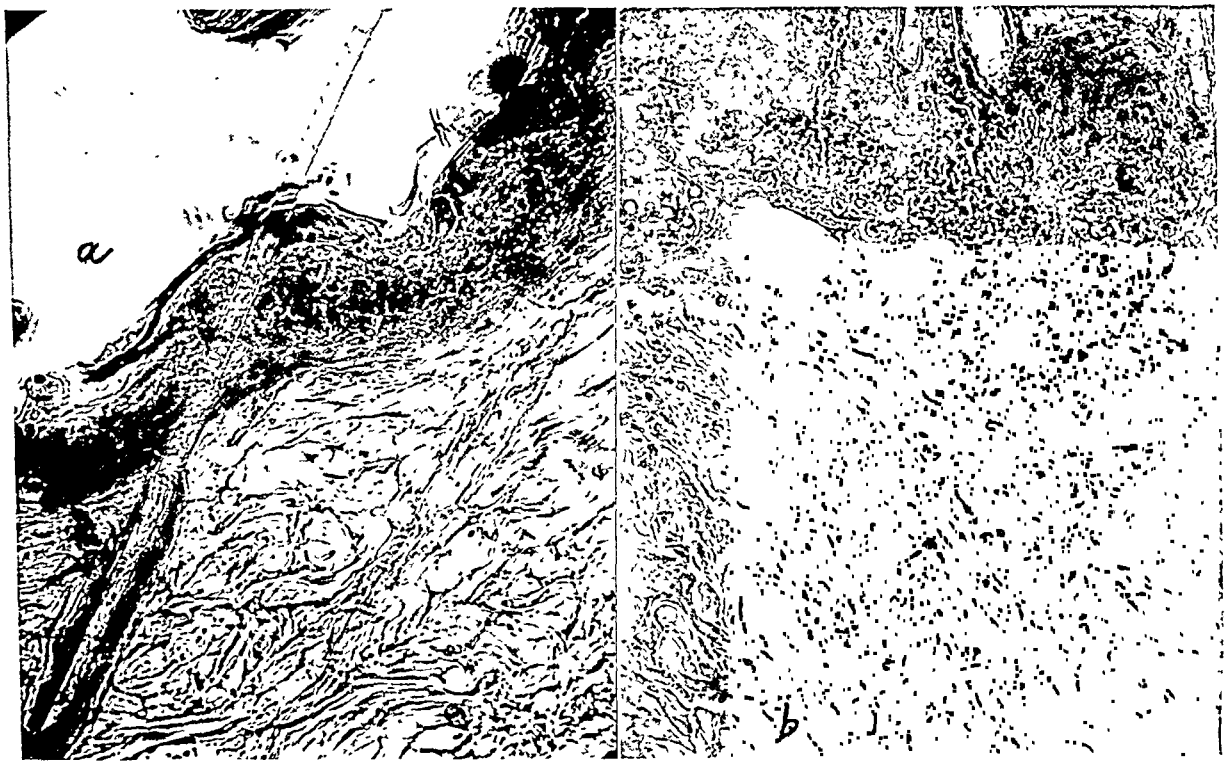
The findings at the 60-day and 90-day periods do not deviate much from those in Group IV.

VI. Exposure to 2,000 r (7 Days).—The outlines of both fields begin to appear. Microscopically, the epithelium in the upper field is slightly thickened; numerous mitoses; many lymphocytes in corium; capillary walls swollen; hair shafts show atrophy. There is nuclear proliferation. The changes in the lower field are similar, but not quite so striking.

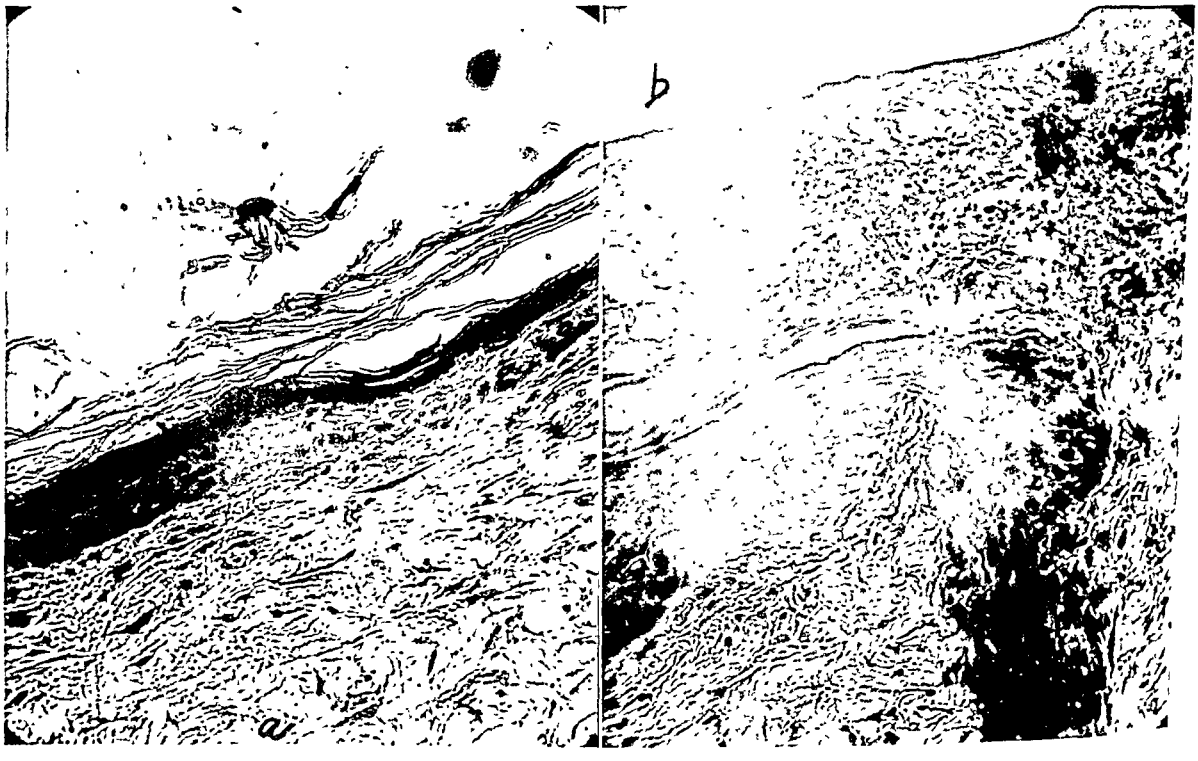
(10 Days).—Both fields are definitely outlined; beginning epilation; erosion in spots in both areas (Fig. 7-*A*). Microscopically. the epithelium in the upper area is thin; cells swollen, with large nuclei; occasional hyaline necrosis; lymphocytic infiltration of corium; capillary walls thickened. The epithelium in the lower field is thin, with some



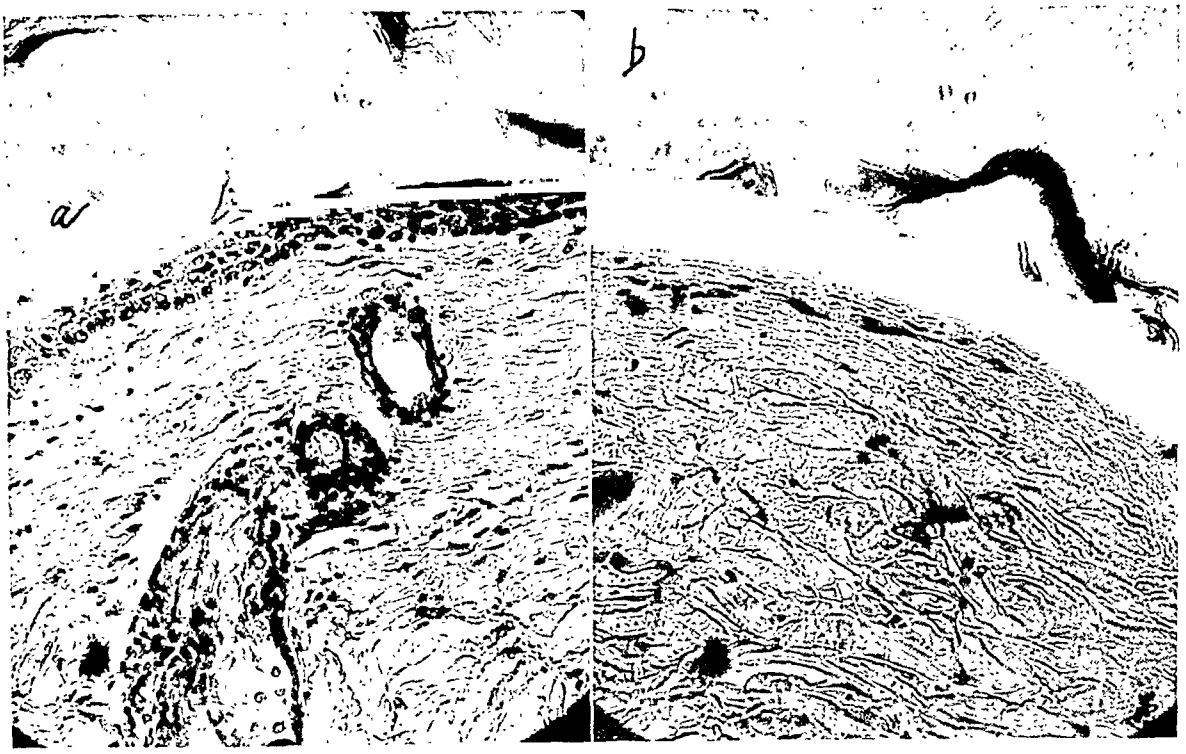
Figs. 8-*A* and 8-*B* Two thousand r. Ten days 8-*A*, upper field; 8-*B*, lower field.



Figs. 9-*A* and 9-*B*. Two thousand r. Fourteen days. 9-*A*, upper field; 9-*B*, lower field.



Figs. 10-*A* and 10-*B*. Two thousand r. Thirty days. 10-*A*, upper field; 10-*B*, lower field.



Figs. 11-*A* and 11-*B*. Two thousand r. Ninety days. 11-*A*, upper field; 11-*B*, lower field.

hypertrophy around edges, otherwise similar to the upper area. In some sections, beginning ulceration in both fields (Fig. 8).

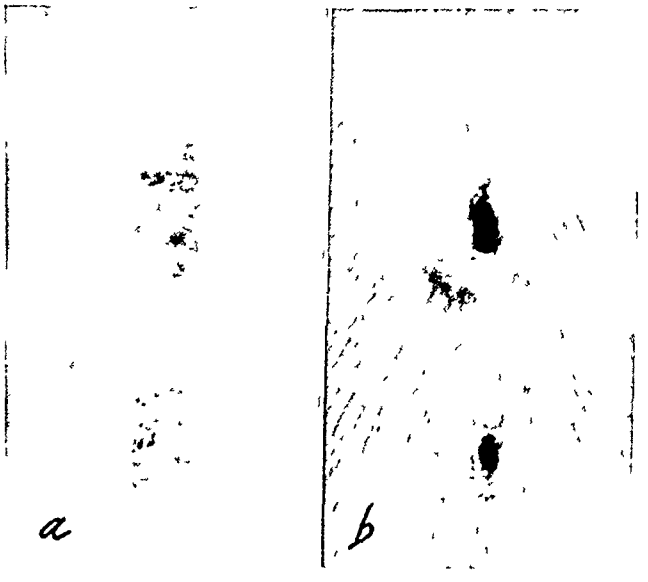
(14 Days).—Ulcer has developed in both areas, more extensive in the lower field (Fig. 7-*B*). Microscopically, there is an ulcer in the upper area, with leukocytic reaction; inflammatory dilatation of the blood vessels; epithelium around edge swollen, with large nuclei and mitoses. It is invaded by lymphocytes and separated from corium by lymphocytes. Hair shafts atrophic, many absent. In the lower field, the epithelium is thick, with irregular cells. Large swollen nuclei and lymphocytes in epithelium and corium. Ulcer (Fig. 9).

(30 Days).—The ulcers in both fields are healing; they are epilated (Fig. 7-*C*). Microscopically, the epithelium in the upper field is slightly thickened, with numerous mitoses; some infiltration of lymphocytes in corium. In the lower area, the epithelium is hyperplastic, with mitoses; several small ulcers; fibroblastic proliferation; hair shafts atrophic or absent in both fields (Fig. 10).

(60 Days).—Both fields are epilated and show pigmentation in spots. Microscopically, the epithelium in the upper area is thickened and there is slight fibroblastic reaction; hair shafts lacking; lymphocytes and leukocytes in epithelium and corium. The appearance of the lower area is similar to that of the upper.

(90 Days).—Both fields epilated, with slight desquamation, and fine hair regrowing in a few spots (Fig. 7-*D*). Microscopically, the epithelium in the upper area is thickened, cells crowded, mitotic; slight lymphocytic infiltration in epithelium and corium, also fibroblasts in corium; few atrophic hair shafts visible. The lower field has not changed much as compared with the sixty-day interval. The epithelium is thickened, also the capillary walls. Both fields present the picture of a definite scar (Fig. 11).

VII. Exposure to 2,400 r (7 Days).—Both fields are faintly outlined, the upper more distinctly. Microscopically, the epithelium in the upper area is thin, with large lobed nuclei; proliferation on edge of field; Lower layer of cells swollen and separated; leukocytic exudate on top of epithelium; capillaries show inflammatory dilatation; slight fibroblastic proliferation; epithelium on edge of section thickened; mitosis;



Figs. 12-*A* and 12-*B*. Twenty-four hundred r. Upper field, 7 K V.; lower field, 60 K.V. 12-*A*, 14 days; 12-*B*, 30 days.

lymphocytes and occasionally leukocytes in corium; slight swelling of capillary walls. In the lower area, the epithelial cells are swollen, with large nuclei; direct division of some nuclei; lymphocytic and leukocytic invasion; hair shafts atrophic; capillary walls slightly thickened.

(10 Days).—Both areas show definite reaction. Microscopically, the epithelium in the upper area is thin; mitosis; few lymphocytes; capillaries slightly swollen; hair shafts slightly atrophic. The epithelium in the lower field is slightly thickened; capillaries dilated, with thickened walls; some lymphocytes; hair shafts atrophic.

(14 Days).—The ulcers are well developed in both areas, perhaps more pronounced in the upper field (Fig. 12-*A*). Epithelium thinned in center of upper area. lymphocytes in corium. In the lower field, the epithelium is thick and invasive; hair shaft epithelium proliferative; lymphocytes and fibroblasts in corium; capillaries swollen. In a number of sections, definite ulcer in both fields (Fig. 13).

(30 Days).—Both areas are epilated. The ulcers have partly healed, with a smooth scar showing desquamation; in spots they are covered by crusts (Fig. 12-*B*). In the upper area, the epithelial layer is thick; mitosis; underlying fibroblastic proliferation; few lymphocytes in corium; scar tissue throughout section. The lower field shows essentially the same microscopic picture, the scar not quite so extensive as in the upper area (Fig. 14).

(60 and 90 Days).—Both macroscopic and microscopic findings are essentially the same

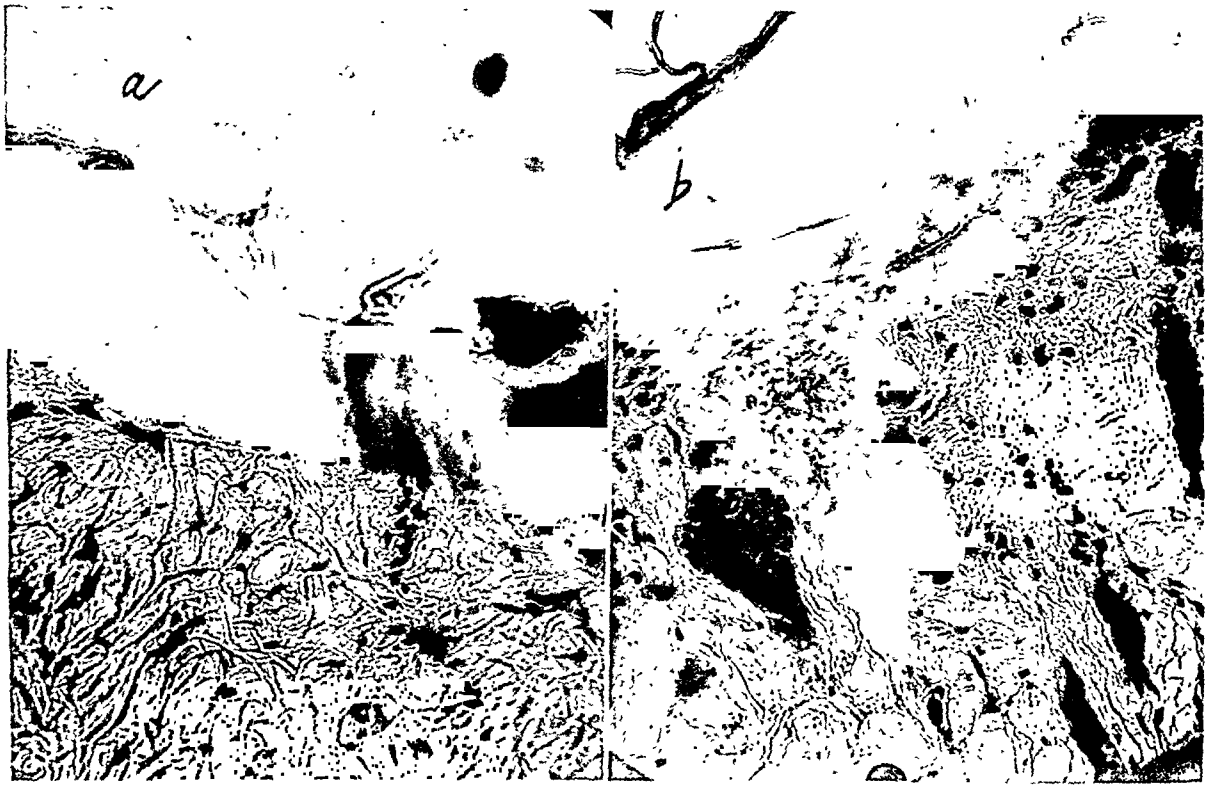


Figs. 13-*A* and 13-*B*. Twenty-four hundred r. Fourteen days. 13-*A*, upper field; 13-*B*, lower field.

as in the previous group at the same intervals.

DISCUSSION

When comparing the macroscopic and microscopic reactions in the different groups of animals, we were impressed by the small amount of individual variation. This facilitates, of course, the interpretation of the results. It seems evident that the two types of roentgen rays in doses as employed in our experiments produce very similar changes in the skin of rats. For both qualities of X-rays, the amount required for a well-defined macroscopic reaction is approximately 1,000 r; perhaps a little lower for the longer wave length. An increase of the dose soon leads to more severe reactions. Between 1,200 r and 1,300 r, erosions and slight ulcerations in parts of the exposed areas could be noted. For doses of 2,000 r and 2,400 r, the appearance of the X-ray ulcer, the time of healing, and the final scar are nearly identical for both qualities. The observation of Hausser and Schlechter (3) that the skin erythema in man does not increase proportionally to the dose if ultraviolet rays or borderline rays are used, could not be demonstrated in our animals. This may perhaps be explained by the difference which undoubtedly exists between the skin of human beings and the skin of rats. Sometimes, the reaction following the exposure appeared first in the upper field (long wave length) and also ran a more rapid course. This was particularly apparent with medium doses. In these groups, however, both fields were epilated and healed with almost identical scars. A daily study of the lesions is necessary for proper interpretation. The comparison of the reactions on one day only might lead to the impression that there was a more severe reaction either in the lower field (See Fig. 7-*B*, 2,000 r, 14 days) or in



Figs. 14-A and 14-B. Twenty-four hundred r. Thirty days. 14-A, upper field; 14-B, lower field.

the upper field (See Fig. 12-*A*, 2,400 r, 14 days). On the other hand, the reactions might be almost alike on one day (See Fig. 6-*A*, 1,500 r, 14 days), followed by a preponderance of the lower area (Fig. 6-*B*, 1,500 r, 30 days), while the inverse holds true in other cases. Some of the animals exposed to 2,400 r were kept alive for one year following the exposure. In not a single one of the seven rats studied during that period could we detect signs of a late reaction. The fields were still well visible, since the epithelium appeared thin and of a silver-white color. In several spots fine hair was growing. This growth was perhaps a little more marked in the upper field. While Herxheimer and Uhlmann (4) conclude from their experiments on human skin that for small doses the effect of roentgen rays of long wave length is partly similar to roentgen rays and partly to ultra-violet rays, we are more inclined to regard the borderline rays as true roentgen rays. This suggests, of course, that all the precautions adopted in roentgen therapy should be extended to Grenz rays.

SUMMARY

1. The skin of eighty rats was exposed to two types of unfiltered roentgen rays produced at 7 K.V. and 60 K.V., respectively. The dose amounted to 500 r, 750 r, 1,000 r. 1,250 r, 1,500 r, 2,000 r, and 2,400 r.

2. The reactions were studied macroscopically and microscopically. It appeared that the changes observed in the skin following exposure to both qualities of roentgen rays in equal doses were very similar.

3. Although it is not advisable to transfer directly the results of animal experiments to human pathology, the conclusion seems justified that roentgen rays of from 1 to 2 Ångströms should be used thera-

peutically as other roentgen rays. Clinical observations support this conclusion.

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SINUSES (THERAPY)

Chronic Maxillary Sinusitis. J. P. Morton. Canadian Med. Assn. Jour., June, 1930, XXII, 808.

The paper is a report of successful results obtained from operative treatment in 73 cases of chronic maxillary sinusitis.

The many methods of examination now available render the diagnosis of chronic maxillary sinusitis a comparatively easy matter. A detailed history is important. Lavage decides the diagnosis if pus is found, but frequently there is no pus, for example, in polypoid conditions. Suction fails to operate in many conditions and is not trustworthy. Transillumination is not conclusive, since, by it, one cannot always judge between thickened mucous membrane and pus content. Roentgen rays give the most helpful information, especially after using lipiodol. The electro-nasal pharyngoscope may often be inserted if there is a good opening under the inferior turbinate; or the right-angled antroscope may be used. Palpation of the mucous membrane with a large blunt-pointed probe often gives valuable information regarding the condition of the mucous membrane and bone. If chronicity is determined, the only legitimate procedure is a radical operation, although occasionally cases of years' standing clear up after a few washings. The results of operation are so satisfactory that the author prefers to err by operating too early. The determination of chronicity is established when it is demonstrated that permanent mucous membrane changes have occurred. These changes consist of the finding of edematous, infiltrated, polypoid, hemorrhagic, or atrophic areas within the antrum.

The type of surgery to be employed is determined by the results of inspection of the mucous membrane of the antrum at the time of operation. If the whole mucous membrane is purulent, with polypoid, hemorrhagic, or atrophic areas, the radical Denker's operation of complete removal of the antral mucous membrane is done. All the bone between the opening of the canine fossa and the apertura pyriformis is also removed. If there are considerable areas of normal or nearly normal mucous membrane, the less radical Caldwell-Luc operation, with nasal flap, is done.

L. J. CARTER, M.D.

POLYPI OF THE ACCESSORY NASAL SINUSES[1]

By FRED JENNER HODGES, M.D., Madison, Wisconsin

RECENT publications by Fraser (1, 2) and Hirsch (3) deal so exhaustively with the subjects of etiology, pathology, diagnosis, and treatment of nasal and intrasinus polyposis, and their attached bibliographies are so very complete, that to review in detail their work would be idle. It is the simple purpose of this communication to present some observations concerning the recognition of intrasinus polypi in the routine examination of the sinuses by the X-ray method.

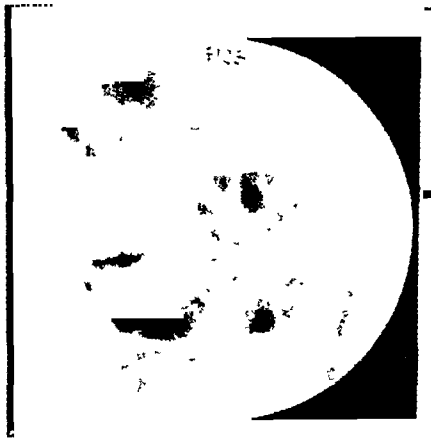


Fig. 1. Right lateral view showing large lobulated or two distinct masses within the right antrum.

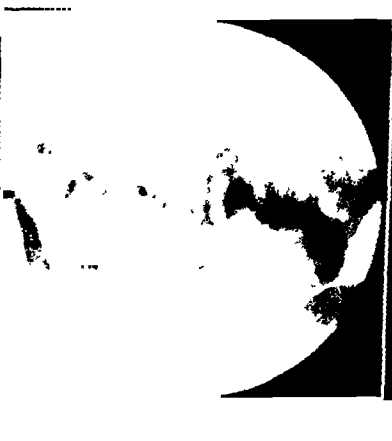


Fig. 2. Same case, showing visibility in Granger view.



Fig. 3. Same case, again showing polyp on the right.

Since the establishment of the X-ray department at the psychopathic hospital for ex-service men, the Wisconsin Memorial Hospital, at Mendota, all patients admitted have been subjected to stereoscopic chest examination as well as examination of the head in dorso-ventral and lateral views. The lateral view is made stereoscopically; two flat films in Granger and Waters positions are made from behind. These examinations have been of value in uncovering silent lung lesions, foreign bodies, dental pathology, and sinus conditions, the presence of which might have been extremely difficult to determine otherwise in patients suffering from various mental diseases. In the films of six hundred such patients the occurrence of intrasinus polyp was not once noted, although various degrees of sinus clouding were rather frequently encountered.

At St. Mary's Hospital, Madison, Wisconsin, nearly three hundred sets of sinus films, made according to the same routine except that a Potter-Bucky diaphragm was used, were examined before a single case presented itself in which the diagnosis of an intrasinus soft tissue tumor mass was made. Nine months later a second case was encountered and the day following a third was seen. The first had by this time undergone operation and through an external window a cyst arising in the mucosa had been removed. Later this same operation was performed upon another case, with similar findings.

A systematic review of 1,000 sets of sinus films at the two institutions resulted

[1]Read before the Radiological Society of North America at the Fifteenth Annual Meeting, at Toronto, Ont., Canada, December 2–6, 1929.



Fig. 4. Medium sized polyp, left antrum; Waters position.



Fig. 5. Clean-cut polyp in left antrum; shows well in Waters position, poorly in Granger. This patient was operated on. After removal of cyst, symptoms of pain over the antrum and frequent colds were relieved.



Fig. 6. Large polyp, right antrum; partial clouding, left antrum.

in the discovery of twenty-four cases of clearly defined spherical soft tissue mass, usually single but occasionally multiple, within the confines of one or both antra. One additional case was later seen with two clearly defined masses within the frontal sinuses, making a total of twenty-five[2] instances (2.5 per cent) of intrasinus polyp. No cases of sphenoid polyp were discovered. In none of these cases have choanal polypi been found by the rhinologist and apparently these have been instances in which the polypi have not yet been expelled into the nose.

THE ROENTGEN APPEARANCE OF INTRASINUS POLYP

A polyp is recognized in the sinus film by its smooth, circular border of relatively short radius. The radius is always shorter than the average radius of the sinus cavity, for, until the polyp completely fills the cavity, some portion of its surface can be seen in silhouette and the curvature of this border will be rather sharply convex. Overexposure of the film reduces the visibility of the mass in direct proportion and in this series was directly responsible in many cases for the original oversight. Concomitant generalized opacity of the sinus cavity is not generally encountered in these cases. Occasionally the shadows cast by the ala of the nose and by irregularities in the upper border of the temporal bone may be confusing, but these can usually be readily ruled out by their lack of smoothness and true circular contour.

THE USE OF LIPIODOL

Undoubtedly opaque injection or suffusion of the sinuses in the hands of competent workers is of tremendous value in studying the sinus cavities. We have not used lipiodol extensively in this field, and, in the first case of this series, when used, the true state of affairs was effectively masked because of the great density of the oil and the relatively small size of the polyp compared to the total capacity of the cavity. The use of diluted oil would probably have resulted

[2]Figures 1 to 9, inclusive, are reproductions of films from seven of the twenty-five cases observed.

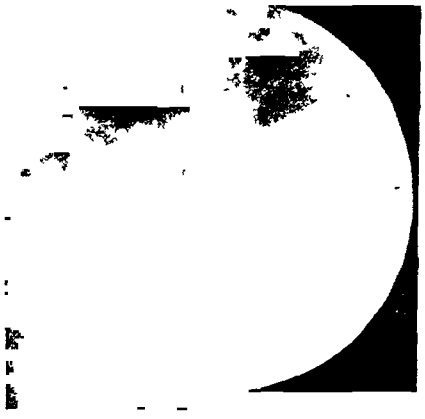


Fig. 7. Medium sized polyp, right antrum; probable multiple polypi, left antrum.



Fig. 8. Medium sized polyp, right antrum. This patient was operated on with considerable relief of symptoms.

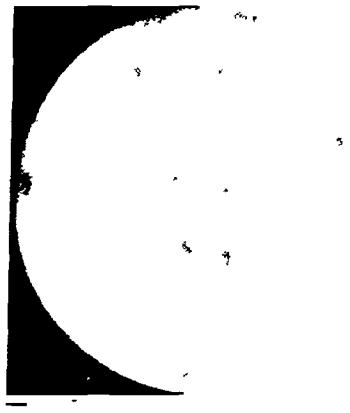


Fig. 9. Two small polypi within the frontal sinuses. These can be clearly seen in the lateral view and show well in stereo.

in perfect visualization. However, the point of interest to the referring physician is that, if properly exposed routine sinus films are carefully studied, polyps entirely invisible to nasal inspection and therefore usually unsuspected, can be demonstrated by the roentgenologist. When found, the accepted method of treatment is window resection and removal, so that further study with opaque injection, while interesting, is non-essential and should be reserved for those cases in which polyp is suspected but invisible by ordinary roentgen technic. The tell-tale polyp shadow is easily overlooked unless the observer is constantly alert, and it is to be remembered that at least three views must be studied, even though the Waters film, which is in such common use, offers the most information as a rule.

If films are made of dried skulls into the sinuses of which small rubber sacks filled with dilute iodized oil have been inserted, it will be found that if the artificial polyp is of relatively small size, it can be clearly seen in the Waters position, no matter where it is located in the sinus. If the polyp is very large, however, it cannot be seen well in this view but may be seen better in the Granger film. The shadow of the malar bone replaces the clear upper zone of the antrum characteristic of the Waters position and makes the recognition of faint polyp shadows difficult. These tumor masses are seen to advantage in the lateral view only when the X-ray beam is tangent to the hard palate—an infrequent coincidence in most routine lateral views.

SUMMARY

1. The discovery of twenty-five cases of intrasinus polyposis among the routine films of a thousand cases is described.

2. Accessory nasal sinus polypi can frequently be identified with certainty in routine X-ray examination of the sinuses without the aid of opaque oil.

3. Polypi are most frequently seen in the antra.

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DISCUSSION

Dr. Amédée Granger (New Orleans): I wish only to add my testimony to that of

Dr. Hodges, when he says that he has not found the lipiodol injection to be necessary for the study of pathology of the paranasal sinuses. My experience during the last seven years bears that out fully. When the sphenoid particularly is to be injected with lipiodol—and I assume that the injection would probably be made with a Sluder needle—I think it is very important to measure on a seven-foot lateral film the distance from the anterior nasal spine to the anterior wall of that sinus, and from the anterior wall of the sphenoid to its posterior wall (anterior portion of the sella floor), because, as was called to my attention by one of our prominent otolaryngologists, the former distance, usually accepted as averaging 8 cm., we have not found correct. In our work at the Charity Hospital, we found the average distance to be 6.5 centimeters. We recall two instances in which the injection was made without taking the precaution of measuring the distance from the nasal spine to the anterior wall of the sphenoid. When the operator perforated the floor of the sella he thought he was puncturing the anterior wall of the sphenoid, with the result that the lipiodol was injected through into the cranial cavity. Fortunately there was no serious result. The patient had a very severe headache for a period of about twenty-four to thirty-six hours, followed, a day or so later, by severe pain in the back and finally a lower lumbar pain which lasted for several days. In another instance, a probe supposedly held against the anterior wall of the sphenoid sinus by an assistant fortunately was seen by the chief of the service, who checked up on the graduated probe and noticed that the distance exceeded 6.5 cm. and became suspicious at once that the probe might not be against the anterior wall of the sinus but against the floor of the sella. A lateral view of the head was made and the probe was found to be actually against the floor of the sella. If the use of the probe had been followed by that of a hand drill or some other surgical instrument, the floor of the sella would have been perforated.

This measurement is readily made. You recognize at once on the plate the tip of the anterior nasal spine to which the septum of the nose is attached. It is readily seen, as are also the curved lines, with convexity toward the front of the head, which are produced by the greater wings of the sphenoid and which lie parallel to the anterior surface of its body, so that they become a landmark for its anterior wall. Even on a six or seven foot film there is a slight magnification, so that the measure you give to the laryngologist is three or four millimeters greater than the actual distance. Fortunately, that slight increase is corrected by the thickness of the soft tissues, as he has to take his measurement from the junction of the septum with the upper lip, and in practice, therefore, his measurements check up absolutely with ours.

INTRAVENOUS PYELOGRAPHY[1]

By A. von LICHTENBERG, M.D., Berlin, Germany

THE demonstration of contrast material in the urinary organs is made possible by two methods: First, through the filling up of these organs by the introduction of instruments into the interior of the body—instrumental pyelography or urography; second, by utilizing renal function as the dispenser of contrast media—excretion pyelography or urography. This can be effected through the introduction of contrast media by mouth, rectum, or vascular system, especially by vein. This latter method, intravenous pyelography, and the disclosures made by it, form the subject of this report.

Intravenous pyelography is entering upon a momentous period of development. Although the idea is not new, experimental knowledge is universally limited, for it is but recently that reliable means have become available; therefore, it is not possible at the present time to form any conclusive opinion, and a report can afford only a glimpse into a newly discovered land. On the basis of over six hundred clinical investigations, and intensive labor in the field of urography, I shall endeavor to convey this glimpse to you. I should like particularly, wherever possible, to state the indications and limitations of intravenous pyelography, and I thank the German Röntgen Society for entrusting to me the presentation of this report.

A few brief remarks relative to the history of intravenous pyelography may be permitted. The first experiments were undertaken by Völcker and myself in 1905, immediately following the announcement of instrumental pyelography. These experiments were not successful, due to the toxicity of the colloidal heavy metals used at that time.

In 1923, Rowntree and his collaborators made public the first promising experiments with excretion pyelography. For this purpose sodium iodid was used. The result of their experiments must be accepted as the first proof that this method, in its essential points, was feasible.

In connection with this publication, I, too, together with Rosenstein, took up the work, using sodium iodid with the aid of pneumoradiography, but found it of no clinical value. The experiments of Volkmann, in this direction, were also without result.

Lenarduzzi and Pecco were the first to ligate the ureter, in animal experimentation, utilizing the blockage for the purpose of increasing the concentration of the contrast substance. This method also had at first only theoretical value. It was Roseno who, through the intravenous administration of an iodin-urea compound, achieved clinical results, and fostered the theory essentially. His method was then supplemented by the researches of Ziegler and Köhler, who added materially to the previously tested compression of the ureter. That Roseno's suggestion did not meet with the expected response was due to the facts that his product was not tolerated without alarming secondary manifestations in many cases, that excretion was considerably prolonged, and that visualization was sufficiently satisfactory only in special cases.

Intravenous pyelography, to be of general clinical value, can be perfected only if one has a non-toxic product that can be excreted by the kidneys in sufficient concentration to assure visualization of the urinary tract with certainty.

Credit is due to Hryntschak, of Vienna, and Lichtwitz, of Altona, that they, independently of each other, made experiments with the selectan preparations of Binz and

[1]Read before the Congress of the Deutschen Rontgengesellschaft (German Röntgen Society), April 27, 1930.

Raeth, and proved that these preparations were especially adapted for use in excretion urography. Lichtwitz's collaborator Swick, under my direction, continued the work upon these grounds. The selectan-neutral hitherto used by Lichtwitz and Swick did not permit the administration of sufficient iodin for good visualization. Excretion was slow, and the results so uncertain that, out of eight suitable cases, a film of the renal pelvis could be obtained in only one instance of calculus obstruction.

Several conferences with Binz led to the selection by him of 5-iodin-pyridin-N-acetic acid sodium, a compound later called "uroselectan" by me. This preparation meets with all the requirements that can be expected of any one medium for use in excretion pyelography. It is quickly excreted, highly concentrated, gives good shadows, and produces no injurious after-effects when the proper amount for intravenous pyelography is administered.

At the Urological Congress, held in Munich the latter part of September, 1929, we presented our report on uroselectan and its clinical application. Since then, further observations have been reported by others which have substantiated our findings.

The technical details relative to the application of uroselectan have been referred to in our publications. I do not here wish to discuss these details in their entirety, but desire merely to state that we inject intravenously, as heretofore, 100 c.c. of a 40 per cent uroselectan solution, and take the first film a quarter of an hour, the second three-quarters of an hour, and the third one and one-quarter hour after the injection.

The use of uroselectan in intravenous pyelography is of threefold value.

(*a*) It affords visualization of the urinary tract, with especial reference to its system pathology and physiology.

(*b*) It affords, through pictorial nuances and qualitative and quantitative chemical analyses, knowledge of the renal function.

(*c*) It affords an insight into the dynamics of the urinary tract by permitting the examiner to observe the expulsion of the medium through the tract.

In connection with (*a*), it is important to know what type of film one may expect from this method.

1. Of course, a diagnostic film can be expected only in cases in which renal function is present, and the density of this film is dependent, in the greatest measure, on the amount of function that exists. Severe bilateral infections of the kidneys, particularly those conditions associated with a damaged purulent parenchyma, give no shadows, or only faint or considerably delayed shadows.

2. The clarity of the film is entirely dependent upon the uroselectan-threshold of the kidney, *i.e.*, upon the concentrated uroselectan-urea solution eliminated by the normal kidney. We have been able to establish in a large number of cases with normal renal function that this concentration amounts to about 5 per cent. But this 5 per cent uroselectan solution by no means produces contrasts as strong as those produced by the 20 per cent solution of sodium bromide, or umbrenal, formerly used in instrumental pyelography; that is, we must not expect very dense shadows even in the best cases. Where damage exists, the intensity of the shadow is diminished. In blocked conditions one frequently obtains more clearly defined shadows than could be expected from the concentration of uroselectan eliminated by the kidney.

3. We must take into consideration to what extent the excretory passages are filled up with the contrast substance, and the state of these passages after they have emptied naturally. In other words, only those parts can be filled which are in the relaxed state of diastole when the injected

substance reaches them, while the contracted parts of the calices, renal viscera, and ureter—those parts which are in a state of systole—can not be seen in the X-ray film. One must always remember that he is dealing with a dynamic condition of the urinary tract, which, as in the case of peristalsis, is continually undergoing change in form. Therefore, there are many instances which, due to the examiner's unfamiliarity with the method, might be construed as defects in the method. On the contrary, they give valuable insight into the normal and pathologic physiology of the excretory urinary passages, and only *appear* to be defects.

As a result of our experiences, we can say that simple disturbances of the renal function are not perceptible by this method. Testing of function by pictorial means is, therefore, not an exact method, but it suffices for the gross clinical diagnosis of surgical lesions. Localization of the infection is possible in one-sided conditions, and often in bilateral conditions it is possible to establish which side is most affected. These films are sometimes sufficient basis for making a clinical diagnosis.

Hypertonia and hypotonia of the excretory urinary passages can be visualized in normal as well as pathologic conditions. The renal picture is much clearer than usual, and in many cases of tubular damage it is particularly clear because of a sort of storing-up in the parenchyma. Nevertheless, a good nephrography is not yet possible by means hitherto employed.

Relative to (*b*), excretion of the uroselectan by the kidney can be followed, aside from the roentgen-ray control, through the control of the excretion of the substance itself, through the control of the iodin excretion, through the control of the increased specific gravity, which can all be regarded as excretion tests in the general sense of the word, and through the fixation of the uroselectan in the blood, which can be viewed as a retention test. All these together present a type of function test of the entire renal function. I will go into these tests only briefly here.

Uroselectan contains 42 per cent of organically bound iodin. Of this injected iodin substance—about seventeen grams for each test—90 per cent is excreted by the kidneys according to the facts established by Swick and the findings of Heckenbach, and the greatest amount of this is excreted within the first two hours after injection. Where renal function is more or less good, fifteen to sixteen grams of iodin are excreted after ten hours. If excretion is delayed over a longer period, then, from a surgical point of view, the general function may be looked upon as being definitely bad. The urinary excretion is considerably increased during the first two hours, but, after the second hour, as the iodin is expelled, diminishes in amount. There appears to be a clean washing out of the uroselectan, and through this, good excretion of the iodin is accomplished, both in excretory disturbances and obstruction of kidneys which are functioning under an increase of urine production and decreased concentration, a condition which may be mistaken for intact functional activity. Dynamic disturbances, which delay or hasten excretion, may also serve as sources of error. Frequently, in bilateral infections and functional disturbances, one can determine only from 50 to 70 per cent of the injected iodin substance in the urine. Without doubt, excretion is here accomplished compensatorily through the liver and intestine.

Through acidification of the urine the uroselectan is separated from the substance. However, the exact quantity in the urine cannot be determined. In the best cases, 70 per cent of the injected material can be verified in the urine. According to the methodical researches of my assistant Heckenbach, this result is too inaccurate to warrant en-

larging upon it for clinical tests. On the other hand, the increase and decrease of the sepcific gravity show good regularity, which furnishes us with particulars similar to those revealed by concentration or attenuation tests. At first the specific gravity rises to 1050-60, and then falls to 1030. It is remarkable, however, that the specific gravity continues to rise even after the greatest concentration in the excretion of iodin has been achieved. Also, after these tests it appears that the choice of the moment—the roentgen-ray control after the injection of uroselectan—is rightfully made, as the best pictorial presentation must naturally in time correspond with the most concentrated excretion.

The H-ionic concentration of the urine is shifted to the side of acidification, and that to 5, 8-5, 2 from the third to fourth hour after the injection, but after the sixth hour returns to 6, 8, without the previously rendered acid or alkaline quality of the urine having played a rôle. This alteration does not occur in poor renal function, as my collaborator, Hughes, has established.

Contrary to our first report, one can find the uroselectan in the blood again. According to the researches of my assistants Tourné and Damm, the uroselectan blood curve rises abruptly during the first two hours and sinks more gradually during the later hours, and—what is of particular importance—no uroselectan is found in the blood after four hours where normal renal function exists. Quantities less than one-half of a gram produce an insignificant reduction of the renal function after four hours; quantities over that amount produce a higher grade of function. The conformity between these results and the other clinical function tests justifies the consideration of the four-hour uroselectan residue in the blood as a retention test.

To support the tests of Schlayer and his collaborators, Tourné and Damm have also made tests to ascertain where the uroselectan can be found in the body. One may say that, in general, the uroselectan is distributed in the body in an excretion depot and a storage depot. The kidney particularly serves as the excretion depot; next in order, the liver. The skin may be regarded as the storage depot. This fact is of value in conditions in which the method is contra-indicated, and the conclusion to be drawn is, that in cases of severe damage to both excretion depots, disturbances may result therefrom. In the light of this, one can explain the fatal case reported by Kalk. In animal experimentation, small animals, like rabbits, die shortly after the ligation of both renal arteries, and that after the administration of an otherwise non-toxic dose of uroselectan, from appearances that point to destruction of the capillaries. There is much injection of the serous membranes with transudate formation in which uroselectan can be found.

Finally, it was of interest to follow the finer mechanism of the uroselectan excretion in the kidney itself. My assistants Hughes and Schaffhauser, under the direction of Prof. Péterfi, punctured the glomeruli of a frog's kidney, and after the injection of uroselectan were able to ascertain the amount of it excreted by quantitative micro methods. Two-tenths of a gram of uroselectan was injected into a frog weighing forty grams; that is, about nine times as much as one would inject into a man weighing seventy kilograms. In the glomerular fluid collected for one-half hour, there was found three gamma (μ) (0.000003 gm.) of iodin. This corresponds to about seven gamma (μ) (0.000007 gm.) of uroselectan. Since there are 4,000 glomeruli in the two kidneys of a frog, the entire amount of uroselectan excreted would be about twenty-eight milligrams, an amount which corresponds to the excretion of the human kidney. Calculations made in connection with

the results obtained by similar puncture of the tubule are not yet conclusive, but one cannot hope for positive results from this test because of many physiological difficulties as well as difficulties in connection with the method employed. One can say, however, that the greatest portion of the uroselectan secretion passes through the glomeruli, which explains excretion disturbances in conditions where the glomeruli are particularly affected.

Neither the coagulation time of the blood nor the rapidity of sedimentation is altered by the injection of uroselectan, therefore it does not appear that any special danger of thrombosis or embolism may arise following its injection. Out of the fifteen hundred cases that came under our observation, only eight developed small thrombi at the point of injection, instances which can, without doubt, be attributed to local injury to the intima.

This slight theoretical deviation was necessary in order to familiarize my readers with the effect of the injection of uroselectan upon the organism. It is of clinical value because the fixing of the four-hour residue in the blood can be utilized as a rough retention test. In a great many respects it is similar to the indican test. From observations made in the study of excretion further function tests may develop. In cases of obstruction, the possibility of storage should, by all means, be taken into consideration.

Damaged glomeruli give bad, or no shadows at all, especially in cases with purulent infection of the parenchyma, many forms of tuberculosis, and tumors. On the other hand, clean obstruction, in tubular destruction, even in a far advanced stage, will give good shadows.

In connection with (*c*), in normal conditions, as in pyeloscopy, one may observe the secretion of uroselectan in serial films. Fluoroscopy, in which Dr. Rave, Director of the Roentgen Department of St. Hedwig's Hospital (to whom I am also indebted for complete film records), is particularly interested, is possible only in cases of severe obstruction, therefore not generally applicable, as the contrast action of a 5 per cent uroselectan-urea solution is not sufficient in fluoroscopy. According to the observations of Schaffhauser, shadows are first produced after the use of a 15 to 20 per cent solution of uroselectan, which is as intensive as sodium bromide or umbrenal. As do Prätorius, Boeminghaus and Weber, we also use uroselectan in this concentration for instrumental pyelography, and can also heartily recommend its use in this form, because the substance is non-stimulating and easily tolerated.

It is as a rule possible distinctly to see the action of the ureters in intravenous pyelography. It is not only peristalsis and its disturbances that can be perceived, but the swinging movements and changes in position of the ureters, angles and loops, contractions and isolated dilatations can be recognized with certainty.

To materially perfect the roentgen-ray examination of the urinary organs would mean that intravenous pyelography could also be of use in those cases in which cystoscopy fails or presents difficulties, or in cases in which catheterization of the ureter, or instrumental pyelography is not applicable or would yield no results, as well as in cases in which these examinations could not be carried out because of possible injury. Orientation of the urinary tract is made possible by intravenous pyelography in patients suffering from stricture, severe bladder affections, hemorrhage, fistula, and in small children. Also in cases in which one hesitates to use the catheter, that is, in acute and chronic inflammatory infections of the

adnexa, in tuberculosis, and in cases of prostatic hypertrophy, the employment of intravenous pyelography is a safe method.

In the following instances intravenous pyelography is indicated from the standpoint of a clinician:

(1) In those cases in which cystoscopy, catheterization of the ureter, and instrumental pyelography cannot be performed because of anatomical, pathological, or technical reasons.

(2) In all cases of ureteral obstruction in which the contrast substance by means of instrumental pyelography does not pass the point of obstruction.

(3) In those cases in which instrumental pyelography cannot be undertaken without risk to the patient. To this group belong those patients whom one wishes to spare the pain of catheterization, and of whose condition one can obtain sufficient information through intravenous pyelography.

PEAK VOLTAGE MEASUREMENT IN DIATHERMY

By ALLAN HEMINGWAY, PH.D., Department of Physiological Chemistry, Medical School, University of Minnesota, Minneapolis, Minnesota

IN the heating of tissues by high frequency diathermy currents, a milliammeter in series with the subject receiving the treatment records the current passing between the electrodes. The current is adjusted by the spark gap or by the impedance in the primary circuit of the 60-cycle transformer to a value sufficient for the dosage. In practice, it is assumed that the current as indicated by the milliammeter per unit area of electrode will give an indication of the temperature increase of the tissues below the electrode.

Recently Kelley (1) has asserted that it is voltage rather than current which determines the heat production below the diathermy electrode. Sampson (2) states that "the high voltage current has a much greater heating value, milliampere for milliampere, than the low one." It is with the intention of investigating quantitatively the effects of voltage variation on heat production in diathermy that the following experiments were undertaken.

In diathermy it is necessary to distinguish between two types of voltage, namely, "peak voltage" and "root mean square voltage." The following diagram (Fig. 1), which is purely schematic and not drawn from an experimental record, will illustrate peak voltage.

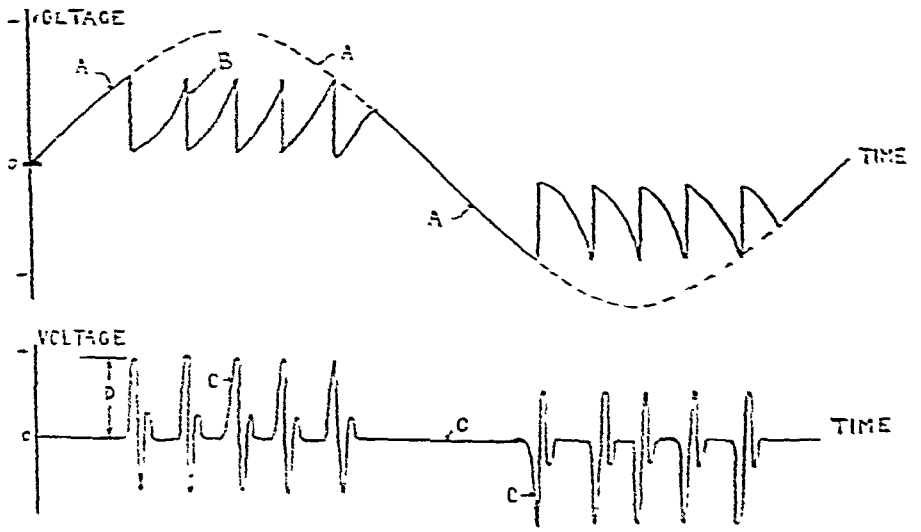


Fig. 1.

The low frequency (60 cycles per second) voltage is "stepped up" by the low frequency transformer to a high voltage of low frequency which is impressed on the condensers. This is represented in Figure 1 by the Curve *A*. When the voltage on the condensers reaches a value sufficient to produce sparking at the spark gaps, a spark discharge at the gaps occurs and the condenser low frequency voltage drops (see *B* in Fig. 1). At the same time an oscillating current of high frequency similar to *C* is produced in the oscillating circuit contain-

ing the air core autotransformer, high voltage condensers, and spark gaps. This high frequency current, whose frequency is determined by the capacity and inductance of the oscillating circuit, passes through the patient. The resultant voltage on the condenser at any instant then will be given as the sum of voltages similar to *B* and *C*. The peak value corresponding to *D* of the oscillating voltage applied to the patient will be referred to as the "peak voltage."

The current passing through the patient also has a wave form similar to the voltage of Figure 1. The current registered by the meter, however, records the "root mean square" current, being the square root of the average of the squared values of the instantaneous current. Corresponding to the "root mean square" current there is a "root mean square" voltage, which also gives an average effect of both positive and negative halves of the voltage cycle.

In Figure 2 is given a circuit to measure this peak voltage. The circuit to the left of the calorimeter represents the usual diathermy circuit with low frequency transformer, high voltage condensers, spark gaps, and air core autotransformer. In parallel with the calorimeter containing a solution of approximately 60 ohms high frequency resistance, which has been shown in an earlier paper (3) to be an average resistance of a patient in diathermy, is a voltage divider. The latter consists of two high resistances, one 142 times as large as the other. Leads from the terminals of the lower resistance go to the filament of a UV 201 A tube and to one end of a high frequency potentiometer. This consists of 10 1,000-ohm resistance units in series with 10 100 ~ units, each unit being an El Menco high frequency resistor. High frequency choke coils are placed in the 110 volt D.C. circuit. The galvanometer in the plate circuit of the tube is a sensitive wall galvanometer with a mirror, lamp, and scale.

The voltmeter operated in the following

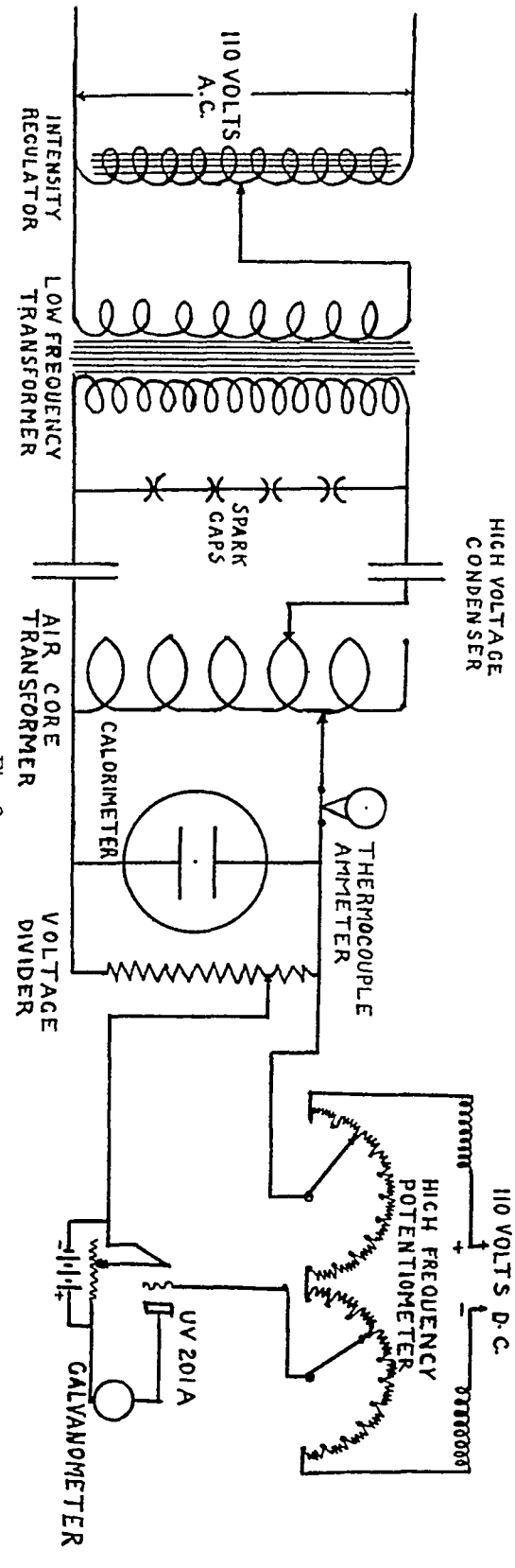


Fig. 2.

manner. Due to the heated filament, electrons were emitted and on reaching the plate gave an indication of a small plate current in the galvanometer. On adjusting the potentiometer to make the grid —4 volts with

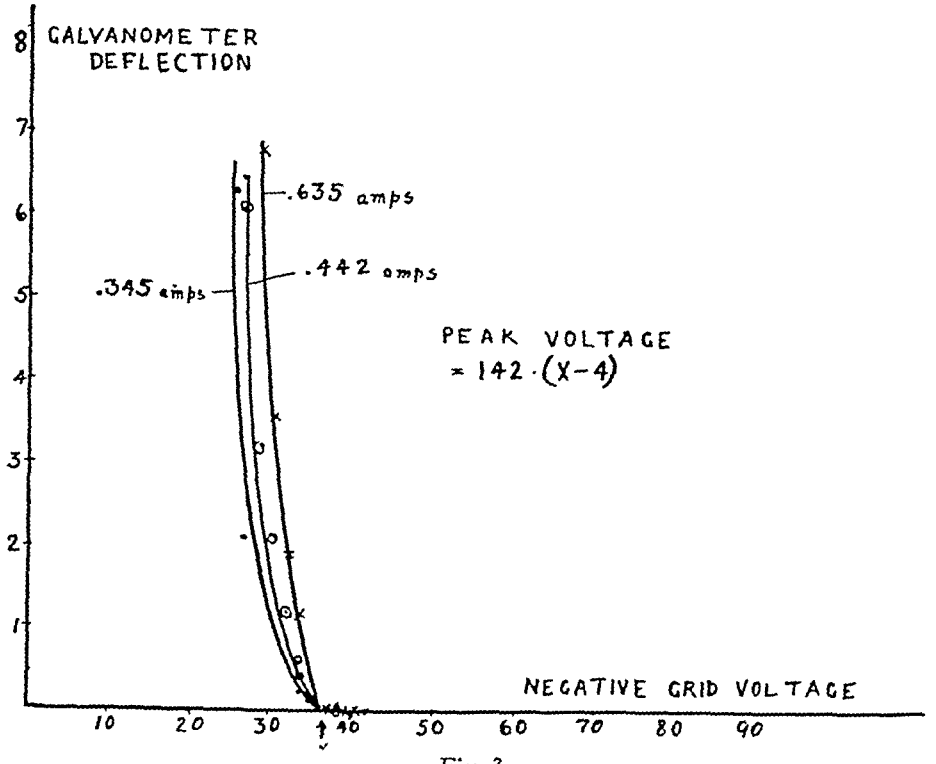


Fig. 3.

respect to the filament, all the electrons were driven back to the filament and none reached the plate; consequently the galvanometer registered zero current. The alternating diathermy voltage similar to that in Figure 1 was now applied between filament and grid through the potentiometer. During the negative half of the cycle all electrons were driven back to the filament. During the positive half of the cycle the positive grid drew electrons to the plate and a plate current was recorded. A negative voltage from the potentiometer now opposed the positive voltage in the positive half of the cycle and this negative voltage was increased until the plate current was again zero. At the point where the plate current became zero the potentiometer negative voltage (except for the four volts to remove the residual current) was just equal to the peak voltage. If the negative grid voltage was decreased, a greater plate current resulted. For a greater negative voltage beyond the peak voltage obviously no plate current would be recorded.

In Figure 3 is recorded the curves taken to measure the peak voltage when the spark gap was fixed and the diathermy current was adjusted by varying the impedance of the low frequency transformer primary circuit by the "intensity regulator." The plate current, as recorded by the galvanometer deflection, is plotted on the ordinate, while the negative grid voltage is plotted on the abscissa. In Figure 4, with the same method of representation, is plotted the values of the peak voltage when the intensity regulator is fixed and the diathermy current adjusted by varying the spark gaps.

The heat energy imparted to the solution was measured by passing a known current

through the solution for a given time and measuring the temperature increase. From the weight of the solution and the container it was then possible to compute the rate of heating the solution in watts. Corrections were made for small radiation losses. A more detailed account of the type of calorimeter used is given in an earlier paper (3). This calorimetric value of the rate at which the solution receives energy is given in the tables as $\frac{\triangle H}{\triangle t}$ where H refers to heat energy in calories and t to time.

The current was recorded by a vacuum thermocouple micro-ammeter system which was calibrated with D.C. Knowing the resistance values from measurements with the high frequency Wheatstone Bridge of Dr. J. F. McClendon[1] (4), the theoretical I^2R values of the heat produced in the solution were computed. In this expression I is the diathermy current and R is the high frequency resistance of the solution.

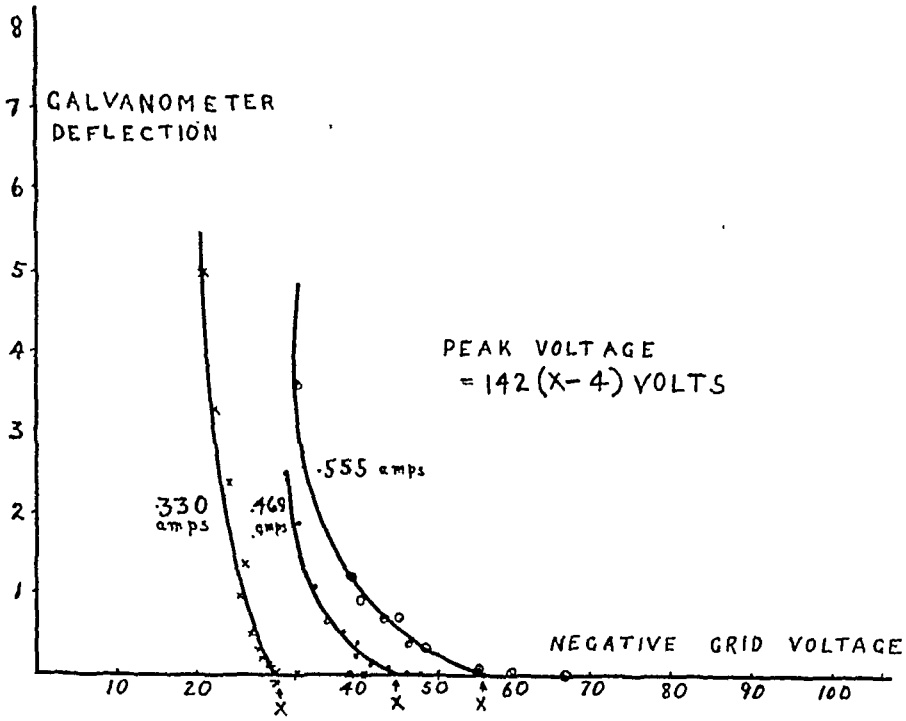


Fig. 4.

TABLE I

I current	$\frac{\triangle H}{\triangle t}$ watts	I^2R watts	Peak voltage volts
0.345	5.8	6.4	4900
0.442	10.1	10.3	4900
0.595	17.5	18.6	4900

TABLE II

0.330	5.5	6.1	3700
0.469	11.3	12.2	5700
0.555	18.7	17.0	7500

In Table I are given values of the heat produced in the solution per second when the spark gap was constant and the current was varied by the "intensity regulator."

[1]For details, see reference.

The peak voltage for these three measurements is recorded in Figure 3, where it is to be noted that the plate current of the vacuum tube becomes zero for the same negative opposing voltage of the potentiometer, and is independent of the diathermy current.

In Table II are given similar values of the energy production, but in this case the current was adjusted by varying the spark gaps while the "intensity regulator" remained fixed. The corresponding peak voltages are obtained from Figure 4.

In Table I it is to be observed that the peak voltage remained constant at 4,900 volts, the spark gap being fixed, but the heat production was determined by the current according to the I^2R value. In Table II the peak voltage was varied, causing a variation in current. In this case also the heat production varied with the current according to the I^2R relation. In the experiments with voltage recorded here it is to be noticed that it is the total heat production which is being measured and not the heat distribution.

In these six experiments the coupling of the air core transformer remained fixed.

RESULTS

The "peak voltage" is determined by the spark gap interval, the wider the gap the greater the peak voltage.

The heat energy of diathermy is given by the I^2R value and is determined by the current and not by the peak voltage. Variation of the spark gaps and hence the peak voltage affects the heat production only insofar as it varies the diathermy current.

In conclusion, I wish to thank Dr. W. K. Stenstrom and Dr. J. F. McClendon for their advice, assistance, and co-operation during the course of these experiments. I also wish to express my appreciation to Dr. H. E. Hartig, of the Department of Electrical Engineering, for his interest in this problem and for many useful suggestions.

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CHOLECYSTOGRAPHY

AN ANALYSIS OF 500 CASES OBSERVED BY MEANS OF THE ORAL METHOD

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CHOLECYSTOGRAPHY has achieved universal recognition as a reliable method in the diagnosis of gall-bladder disease. It has made possible the diagnosis of many obscure gall-bladder conditions which could not otherwise be recognized. The test furnishes not only a means of ascertaining the functional activity of the gall bladder, but presents a relatively accurate anatomical picture, which is essential in the diagnosis of disease of this organ. Attention should also be directed to the fact that it may even reveal a normally functioning gall bladder, provided the pathological process has been eradicated. This had occurred in several instances in our series: the gall bladder functioned and appeared normal several years following the removal of stones.

However, the diagnosis of gall-bladder disease by this method is not infallible and should be considered together with the clinical data, in the same way as any other laboratory test. There are differences of opinion as to its reliability, but as Kirklin (1) well states: "The variances are due primarily to the lack of knowledge as to where the line should be drawn between the normal and abnormal gall bladder, both anatomically and functionally." There are also differences of opinion as to the method of administration of the dye, some preferring the intravenous, while most roentgenologists advise the use of the oral method. Although recognizing that the intravenous method is slightly more accurate, its slight advantage in accuracy does not appear to compensate for its disadvantages. As a matter of fact, the results of cholecystography obtained by either the oral or intravenous method differ but to a slight degree. They depend as regards both methods in a large measure upon the roentgen technic and interpretation Graham and his co-workers (2), Case (3), and others recommend the intravenous method as being the most reliable, but on account of the ease with which the oral procedure is performed and owing to the lessened severity of the reactions produced by the dye, this latter method is preferable according to my experience.

The reliability of cholecystography is now unquestioned, regardless of the method employed. In some instances the slight difference obtained by the two methods may be due to faulty roentgen technic and interpretation. On the other hand, it is quite possible to obtain abnormal results even though the gall bladder may be perfectly normal. Plummer (4) observed that a certain type of patient characterized by certain stigmata, that is, easy fatigability, achlorhydria, low basal metabolic rate, is likely to respond eccentrically to cholecystography, the shadow being often faint or absent in these cases.

The results of cholecystography by the intravenous method have been reviewed by Graham (5), who compiled 561 cases, with operative findings. Of 446 cases, 97.8 per cent were proven correct; but in the entire group the total was reduced to 90 per cent. He further states that a correct diagnosis of the normal gall bladder may be arrived at in only 74 per cent of cases. Case (6) notes the operative findings in 277 cases by the intravenous method, with a total correct diagnosis in 90 per cent. He found the greatest

accuracy in the cases in which there was an absence of shadow (97.5 per cent); in the non-calculus cases (83.6 per cent) and in the normal there were but 83.4 per cent of positive results. Kirklin (1) in a series of 506 cases studied by the oral method obtained a total correct diagnosis in the entire series of 87.3 per cent. It is also interesting to note that the presence of stones was proven by him in 98.4 per cent, while in cholecystic disease 79 per cent showed marked evidence of disease without stones. In the group revealing slight pathologic changes the test was positive in only 66.6 per cent. Of 111 normal gall bladders which came to operation he noted an error in 24.4 per cent. Lockwood and Skinner (7), in an analysis of 1,500 cases examined by the oral procedure, found that of the pathologic cases 96.4 per cent were proven correct at operation. Hardman (8), Robins and Goldberg (9), and Lord (10), also employing the oral method, report their confirmed correct diagnoses ranging from 85.4 to 93 per cent.

TECHNIC

The technic must of necessity be a simple procedure in order to obtain the patient's complete co-operation. He is given a printed list of instructions, with the explanation that every detail must be carefully followed. In order to standardize the technic we advocated a method in 1926 (11) which we have since followed with satisfactory results. We have especially stressed several points which the patient must follow in order to obtain reliable roentgenograms of the gall bladder. The patient is impressed with the importance of taking all the capsules of tetraiodophenolphthalein, regardless of manifestations such as nausea or vomiting, and of abstaining from food or medicines.

The oral procedure is performed similarly to that followed with but few exceptions in other clinics. If the liquid or powdered dye is given in one dose, the same procedure is carried out as with the use of the capsules. Although the former is somewhat simpler, we have employed the capsule as a routine, which, according to my experience, gives more satisfactory and uniform results.

No previous preparation of the patient is necessary. Two plain films are usually made of the gall-bladder area before the dye is administered in order to observe the presence of possible positive stone shadows or a visible gall-bladder shadow, and also to study the films in comparison with the cholecystograms. The patient is then instructed to take half of the capsules at 5 P. M. with a meal consisting of two soft boiled eggs, one glass of milk, and one slice of bread and butter. Two hours later he begins to take capsules at the rate of four every fifteen minutes until all the capsules are administered. After the last capsule the patient is advised to lie on his right side for an hour. He is instructed to return for X-ray examination on the following morning at 9 A. M. on a fasting stomach.

According to my experience, when half of the capsules are taken with the evening meal, very little digestive disturbance is encountered. The fatty meal is also required inasmuch as it stimulates the contraction of the gall bladder and thereby discharges an excessive amount of alkaline bile into the duodenum, which aids in transforming the acid compound of the dye into its soluble salt. The acid compound is insoluble and is not absorbed, while the alkaline salt is readily absorbed in the intestinal tract.

In sixteen hours the patient returns for the roentgen examination; at this time a series of five films is made, three on deep inspiration and two on deep expiration. This procedure is highly important for many reasons; first, it demonstrates the mobility of the gall bladder and whether or not a shadow in the gall-bladder area shifts with the

gall-bladder shadow; secondly, changes in respiration will ofttimes reveal the gall-bladder shadow to be poorly outlined on inspiration, while on expiration the shadow may become very distinct, or *vice versa*. On the other hand, the gall bladder may be overshadowed by the vertebræ or by a dense psoas muscle, which, on shifting the position, changes, whereupon the shadow becomes more clearly visible. Then, again, the shadow of the liver and kidney may interfere with the visibility of the filled vesicle, and, finally, the gall bladder may be overshadowed by gas or dye in the colon, which at times becomes very confusing. To overcome these difficulties the shifting of the gall-bladder shadow is an extremely valuable aid in the diagnosis. A lateral or oblique view of the gall bladder is at times necessary to complete the study.

Normally the gall-bladder shadow is of even density, varying in different individuals. It is homogeneous and regular in outline. Variation in density of the shadow is an extremely important sign in the early recognition of gall-bladder disease. There is a wide latitude in what is termed normal density, however, and this results in an increasing difficulty in the diagnosis. This may be an essential factor in the many errors of interpretation. There is a type of shadow, faint in appearance, apparently shading off into the other organs, which must be considered, according to my experience, as of value in the diagnosis. This sign, although not infallible, may be of some importance. There has been a great deal of confusion regarding the terms "lessened density" and "faint shadows." A shadow of lessened density which is clearly outlined and homogeneous and contracting normally must be considered within normal limits, while a persistent faint shadow shading off into the other organs must be looked upon as abnormal. The diagnosis of gall-bladder disease from variations in density, according to Case (3), is of little importance when applied to the oral method, due to the impossibility of determining the amount of dye which has been absorbed. In my experience, the administration of the maximum dose of the dye by the oral procedure, together with a fatty meal, eliminates this factor of absorption in most instances, and hence the density of the shadow becomes more significant and can be taken into consideration in the diagnosis. The high percentage of correct diagnoses by the oral method proves the correctness and the efficiency of this procedure.

The contraction of the gall bladder in from one to two hours following a fatty meal is an important test of its function. If the gall bladder fails to fill, the examination is concluded. When the gall bladder is filled, the patient is given a fatty meal, two films being made an hour afterward.

Contraction of the gall bladder varies in different individuals. Normally the vesicle contracts from a narrow cord-like shadow to one-half of its original size, but at times the shadow may be absent following this meal. Occasionally the vesicle does not contract at all or contracts poorly or irregularly, due to the presence of stones or a diseased condition. As a result of a diseased and thickened gall bladder, the shadow may not vary in size or may diminish but little, indicating a sluggishness of its contractile power. Frequently under normal conditions the contracted vesicle shadow becomes denser than the original gall-bladder shadow.

Tetraiodophenolphthalein administered in five-grain enteric-coated capsules was utilized in this series. The doses varied in different individuals, depending upon the weight and stature of the patient. The dose is given uniformly by body weight, as a rule, as follows:

100 to 110 pounds.....12 capsules
110 to 125 pounds.....15 capsules

125 to 140 pounds.....16 capsules
140 to 180 pounds.....18 capsules
180 to 190 pounds.....20 capsules
190 to 210 pounds.....22 capsules
210 to 230 pounds.....25 capsules

From 12 to 26 capsules may be given. In order to obtain uniform results the maximum dose of the dye is recommended. The dye is harmless when given orally, and, since there is at times a question of how much of the dye is really absorbed in the intestinal tract, the larger dose fully allows for adequate absorption. In one instance 36 capsules were given to a patient without any ill effect.

A high gastric acidity may produce a chemical change of the dye in some instances, which undoubtedly interferes with the filling of the gall bladder. We have found, for instance, that in dogs a satisfactory gall-bladder shadow can be obtained when the gastric juice is reduced by tying off the duodenum, but no shadow can be obtained when the dye is given orally (12). In thirty instances in which the gastric analysis and operative findings were recorded by us (12), the acidity was found to have but little bearing on the filling or non-filling of the gall bladder, except that it may lessen the density of the shadow to some degree. Eusterman (13) maintains that the gastric acidity interferes with normal visualization, especially in cases of duodenal ulcer. In a large series he reports that 41 per cent of the proved positive errors occurred in patients with duodenal ulcer in whom the gall bladder was found objectively normal at operation. Again, Hines (14) records 90 cases on which gastric analyses were made; eight were found with achlorhydria, revealing abnormal gall-bladder shadows, while in seven no shadows were present. He also cites three cases of achylia in which the intravenous test failed to visualize the gall bladder. However, Davis and Talley (15) do not confirm these findings.

There are practically no contra-indications to the use of this method of diagnosis by the oral procedure. Jaundice is not a contra-indication, and, in our experience, no ill effects have been observed in the many cases in which this test was utilized. Pregnancy is not considered a contra-indication inasmuch as the dye produces no ill effect upon either the fetus or the mother.

It is my purpose in this communication to analyze the data obtained in a series of 500 cases of suspected gall-bladder disease and evaluate the reliability of the test.

Of the 500 cases, cholecystographic studies yielded the following: 287 cases revealed abnormal findings and were diagnosed as pathological, while 213 were diagnosed as normal. The gall bladder filled in 358 cases, 116 of which filled poorly and 242 filled well. In 142 cases the gall bladder failed to fill. In 57 instances gallstones were found, 30 of which were of the negative type and 27 of the positive type. In 302 cases of filled gall bladders, 208 contracted normally, 46 abnormally, and in 47 the vesicle shadow was absent following a fatty meal.

Eighty-six (or 17.2 per cent) of the cases came to operation; in 81 (or 94.2 per cent) the diagnosis was proven correct. Of the 81 proved operative cases, 68 were pathological and 13 were normal. In five instances an error of diagnosis was made; in three of the five instances the diagnosis of pathology was made on poor filling of the gall bladder, and in the other two the error was due to faulty interpretation.

Of the 86 operative cases, 37 showed an absence of the gall-bladder shadow in the 16-hour examination. At operation, 30 of these revealed stones, and in 7 cholecystitis was found. Of the 49 filled gall bladders which came to operation, 24 revealed stones, 7 cholecystitis, and 18 were found to be nor-

mal. It is also of interest to note that of the 49 cases of filled gall bladders, the roentgen diagnosis of pathology was made in 20 instances on poor filling, in 7 on negative stone shadows, and in 6 on positive stone shadows. Normal findings were noted in 16 cases.

It is obvious from these findings that the highest percentages of correct diagnoses were confirmed in the cases which showed evidence of stones and in those which showed an absence of the gall-bladder shadow. The few errors which do occur are usually in the poorly filled and in the normal cholecystographic tests.

Jaundice occurred in 12 cases and in every instance the gall bladder failed to fill. Robins and Goldberg (9) cite 9 instances of catarrhal jaundice which revealed no shadow, and on re-examination, after the termination of the jaundice, some of the cases showed normal filling of the gall bladder.

Vomiting occurred in 84 (or 16.8 per cent) of our cases. In no instance could vomiting account for the non-filling or poor filling of the gall bladder, regardless of the time when the vomiting occurred, provided the full dosage had been taken. Occasionally a denser shadow was noted in cases that vomited. Diarrhea occurred in but 30 instances in this series.

CONCLUSIONS

1. Oral cholecystography is a reliable test in the diagnosis of gall-bladder disease.
2. Eighty-six cases came to operation; of these, a total correct diagnosis was made in 94.2 per cent.
3. The highest percentages of correct diagnoses occurred in cases of stones and in the gall bladders that failed to fill.
4. The diagnostic errors occurred in the cases with poor filling or faint shadows.
5. A normal cholecystographic appear-

TABLE I

500 Cases	287 Pathological 213 Normal
358 Gall bladders filled	242 Filled well 116 Filled poorly
142 Gall bladders failed to fill	
57 Cases revealed stones	30 Negative stone shadows 27 Positive stone shadows
302 Filled gall bladders	209 Contracted normally 46 Contracted abnormally 47 Absent

TABLE II

Operations, 86 cases (or 17.2 per cent)	Correct, 81 (or 94.2 per cent)
Errors, 5 cases (or 5.8 per cent)	3 Poorly filled 2 Faulty interpretation
37 cases showed an absence of gall-bladder shadow in 16 hours	
Operation revealed	30 Stones 7 Cholecystitis
49 cases with filled gall bladders	
Operation revealed	24 Stones 7 Cholecystitis 18 Normals
Roentgenologically, the 49 cases revealed	
20 Cases poorly filled	16 Normals 6 With positive stones
7 With negative stones	

ance of the gall bladder may in a very small percentage of cases represent a false normal.

6. With proper roentgen technic and interpretation, the diagnostic errors may be minimized.

7. Although a high percentage of correct diagnoses of gall-bladder disease is revealed by means of cholecystography, this method of examination must be considered in the same light as any other laboratory test—that is, in conjunction with the clinical data.

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THE CLINICAL SIGNIFICANCE OF ROENTGENOLOGIC FINDINGS OF THE NON-MALIGNANT COLON[1]

By SIDNEY A. PORTIS, S.B., M.D.
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THE increasing literature on the colon has brought forth many views and ideas regarding the roentgenologic aspects. The clinical significance of these findings has been open to much debate. Many authors have elaborated on the abnormalities of the colon—congenital and acquired—and have tried to attach increasing clinical significance to the evidence presented. There may be some substantiation for their arguments, but I have not been overwhelmed by their points of view. Many clinical entities which were formerly unlabeled are now ascribed to the "cecum mobile," the "sigmoid mobile," and the "markedly prolapsed transverse colon."

Clinical manifestations, obscure as they may at times be, now fall into the category of colonic disease. I think the pendulum has swung too far in the present direction. What has transpired in these patients, apparently and formerly healthy, to produce the symptom-complexes? Has a mobile cecum, present since birth, associated with a normal development, suddenly become a potent factor, or is it, as might more rationally be suspected, just mirroring what is going on in the mechanism as a whole? I grant you that abnormalities and redundancies exist, but do they play the exalted rôle that many clinicians believe? Kantor has written at length on the variations from normal, quoting from statistics of his own carefully controlled observations. I do not doubt but that his observations are correct; however, I am not completely in accord with all of his conclusions regarding the abnormalities of the large bowel. I am, however, particularly interested in his observations on ileal stasis. That it exists is a common roentgenologic observation; its clinical significance, however, is still debatable. Personally, I believe that stasis here, with or without surging, is of definite clinical import. Many toxic manifestations may be referable to this part of the bowel. Kantor roughly summarizes ileal stasis as due to the following causes:

"1. Ileal stasis is commonly associated with mechanical obstructions due to kinks or adhesions (Lane, Jordan).

"2. Ileal stasis is commonly associated with acute or chronic appendicitis (Hurst, George, and Gerber).

"3. Ileal stasis is associated with insufficiency of the ileocecal valve (Case, Kellogg).

"4. Ileal stasis is associated with constipation, particularly in the proximal colon (Cole)."

The stasis due to inflammations in and about the appendix is especially interesting, and Kantor, like many others, finds it as a result of a previous appendectomy. That the appendix should be removed in acute conditions needs no elaboration. The removal of a so-called chronic appendix, with definite roentgenologic and clinical evidence, is open to some debate. Once the diagnosis is made, one should not rush to surgery. If you are convinced that it is an important part of a patient's clinical picture, and, after thorough dietary and medical management there is no improvement in the symptoms, one may be justified in advising the removal of the appendix; but the wholesale removal of chronic appendices based only on roentgenologic data may lead to many com-

[1]Read before the Radiological Society of North America at the Fifteenth Annual Meeting, at Toronto, Ont., Canada, Dec. 2–6, 1929.

plications and especially to ileal stasis. This may prove very troublesome and give even more pronounced symptoms.

The colon as it exists is subject to its intrinsic nervous mechanism, with or without cephalic stimuli, to hematogenous and chemical stimulants, to the character of its contents, and disease *per se* of its walls. Many cases of constipation may be due to faulty diet, but to conclude that diet alone in its local action on the colon is the only factor needs more elaboration. Hypertonicity of the bowel is more often a part of systemic disease than a local disease of the colon. The same may be said of hypotonicity. How many patients are treated for colitis for years, with presumable roentgenologic evidence to support it, only to have careful examination of the gastro-intestinal tract reveal a proven case of achylia gastrica! The simple addition of hydrochloric acid to their regimen brings about normal bowel movements. The so-called vagotonic individuals need more than colonic therapy to rid them of their vagotonicity.

We often see bowel manifestations in systemic disease. The more recent interest in vitamin deficiencies and their associated colonic disturbances can well illustrate this point. Patients presumably thinking they are on a normal ration, are found, on closer scrutiny, to have an avitaminosis. The hypertonic bowel in thyrotoxicosis, with its associated diarrhea or constipation, is another example. How often we are called upon to examine a patient who has had long-continued treatment for colitis, because the roentgenologic findings are suggestive, and, on careful investigation, we find the patient a thyrotoxic one.

I have been particularly impressed with the method of drawing conclusions as to the functions and abnormalities of the bowel with different methods of examination. The downward progress of the contents seems a more logical method of investigation than the use of a barium enema when we are studying motility and abnormalities of function—how the bowel acts when full of contents under normal propulsion, rather than the evidence presented by a barium enema in a perfectly cleansed condition. Let me emphasize again that I am talking about disturbance of function. The observations at twenty-four, forty-eight, seventy-two, and ninety-six hours are more significant to me than the observations of a barium enema, and these should consist of both fluoroscopic manipulation and radiographic evidence. When I have such evidence I try to fit it in with the clinical picture, and study what has been going on in the patient as a whole to bring on this abnormal function. Therefore, to draw conclusions on just the findings in the bowel without a knowledge of the patient's condition may be a hazardous procedure. However, this same view of definite intrinsic or extrinsic involvement of the colon cannot be held in the same light. The organic disturbances other than malignancies and their roentgenologic evidences are of definite clinical import. Our understanding of ulcerative colitis—its extent and degree of changes—can be more accurately pre-operatively measured than before the advent of this evidence. The early changes in the bowel wall, the loss of haustral markings, the "feathery, moth-eaten" appearance of the column of barium, are very enlightening. To see the same bowel return to near-normal in those cases responding to therapy is very gratifying. The contour of the bowel in these long-standing cases of so-called mucous colitis presents definite roentgenologic evidence. The contour of the cecum in ileocecal tuberculosis, which was formerly known only at operation or necropsy, is now available. However, this evidence is only a link in the chain, because, in the absence of pulmonary tuberculosis, the diagnosis is indeterminate by roentgenologic evidence. A tuberculoma, retrocecal

appendix, appendiceal abscesses, mesenteric adenitis, carcinoma, and idiopathic infections are differentiated with difficulty and then only with clinical aid. However, irritability may be an early finding and subsequent appendectomy may result in sinus or fistula formation. Therefore, an irritable cecum may be of definite clinical import.

The presence of diverticulosis, either congenital or acquired, has assumed greater clinical significance. The association of arthritis with either local or multiple diverticula, with consequent long-continued retention, has been recognized. The removal of these diverticula at times has greatly influenced the course of the disease. The diverticula of the sigmoid, when localized, are of especial interest. I have seen cases which, when early, were benign, yet later, years after, showed evidence of malignant transformation. When these diverticula occur they should be looked upon as potential sources of carcinoma. Early, these cases as a rule show no evidence of occult blood in the stool, while later, as malignant transformation takes place, the occult blood becomes persistently positive. At this time the other clinical manifestations of malignancy present themselves. I particularly warn these patients that they should return for frequent clinical observations, so that their clinical picture may be carefully noted.

I have purposely left out of this discussion any mention of malignant conditions of the colon, because when they are suspected the patient should have the benefit of an exploratory operation, and I do not think this issue should be debated. Syphilis of the colon, if it exists, more often involves the rectum and may result in stricture formation. Neisserian involvement, with its external evidence, may be very confusing. The clinical and laboratory evidence in each of these conditions helps to differentiate it from other organic disease.

I have tried to express the clinical attitude toward these roentgenologic findings. I know many disturbances are attributable to the large bowel, but I often wonder whether or not the camouflage diagnosis of colitis in the absence of organic findings is a justifiable one; if patients who present redundancies are not often wrongly classified, and whether some systemic disease is not overlooked in our zeal to accept the roentgenologic evidence. Clinical diagnosis has far outdistanced our knowledge of colonic physiology. When we know more about the interpretation of these findings, we then—and then only—will make more accurate clinical diagnoses.

DISCUSSION

DR. SAMUEL BROWN (Cincinnati, Ohio): I wish to congratulate the author on his very valuable paper; but one thing I do not understand. Dr. Portis has emphasized the importance of the examination of the bowel from above, and yet every specimen he presented was taken from below.

DR. MAURICE FELDMAN (Baltimore): About 10 per cent of our examinations revealed colitis, in 500 cases of mucous colitis that we have reported. In making the examinations we have studied a large number of them by both methods, by the use of the barium meal and the colonic enema. We found in many cases a string sign in the lower bowel, which is very suggestive of this colonic condition. Frequently no sign could be found other than a feathering of the bowel, in mucous colitis.

In the diagnosis of carcinoma of the esophagus the liquid and semi-solid meal is necessary. Both will descend rapidly in ordinary cases. If we would use the semi-solid meal in all cases as a routine, I am sure we would find more early cases of carcinoma of the esophagus.

DR. H. A. CHAPIN (Jacksonville, Ill.): The importance of a careful study of the colon cannot be over-estimated. I believe the tendency of radiologists has been to under- rather than to over-examine gastro-intestinal cases. We permit the referring doctor or the patient to hurry us in our examination, and many times I think radiology falls into disrepute because we do not make a sufficiently long and careful study, and, possibly, check up on these cases.

DR. PORTIS (closing): I am glad to arouse some clinical interest, because that was my main reason for presenting the paper. I emphasized, when I was discussing the disturbances of function, and anomalies, that I was looking for function and not for pathology of the wall, and that I much prefer to use the downward progress of the column of barium as a means to this end. The slides were used purely to show evidence of organic disease and that is the reason that they are shown with the use of a barium enema. It is a common observation that when the purpose is to show defects of the gut, it is better to use a barium enema than to observe the downward progress in the barium meal given by mouth. I use the combined methods of observation in studying the colon, but, clinically, the important fact is that, other than as a study of organic disturbances of the bowel *per se,* the barium enema has not given reliable data. The term "colitis" is so misused—and there are no roentgenologic data to support it as a rule—that we cannot depend upon the roentgenologic evidence in making a diagnosis of the symptom-complex called "colitis." However, clinical diagnosis has far outdistanced our knowledge of colon physiology, and until it reaches the same level we will not know much more about the diseases of the colon.

Redundancies do exist, but what part do they play in the symptom-complex of the patient? It is purely a matter of conjecture on the part of the physician who tries to emphasize the importance of redundancy in producing the symptom-complex in that patient.

I do not believe that any one should accept the roentgenologic evidence as 100 per cent correct, but I would much rather trust to roentgenologic findings in or about the cecum in studying appendiceal disease than to rely merely on palpating the abdomen. How often have we thought that we palpated a high-lying appendix, while by roentgenologic evidence it is shown to be low down in the pelvis! The only accurate knowledge that we have to-day that pathology exists in or about the cecum is from roentgenologic evidence. We believe that the patient may have trouble there clinically, but the actual knowledge comes through the roentgenologist. That is why 24-, 48-, 72,- and even 96-hour observations of the cecum and bowel are of distinct clinical importance. Whether chronic appendicitis exists as such, as many clinicians believe, is not a matter for us to debate this afternoon. However, chronic appendicitis does exist in many cases, and, with combined clinical and roentgenologic evidence, it may be justifiable to advise the removal of the appendix. However, very often the evidence gained in the fluoroscopic room is more important than the clinical evidence. On this basis it may be justifiable to remove a diseased appendix even though the clinical evidence is lacking.

PHYTOBEZOAR[1]

By R. P. POTTER, M.D., Marshfield Clinic, MARSHFIELD, WISCONSIN

THE term "phytobezoar" is derived from the Greek word φυτον, meaning *plant*, and the Persian word "bezoar," having reference to the concretion found in the stomach and intestines of animals. Therefore, the food-ball which is occasionally found in the human stomach is called a "phytobezoar."

The phytobezoar consists of the skin, seeds, and fibers of fruit or vegetable matter, such as persimmons, prunes, salsify, and celery. The hair-ball frequently found in the stomach is also a bezoar, and may be either of two varieties—one made up solely of hair is called a "trichobezoar," and one made up of hair and food is called a "trichophytobezoar."

The trichobezoar, or hair-ball, is quite common, a large number being reported. The phytobezoar, or food-ball, is not common, only five cases being recorded up to 1923. In 1923 W. E. Hart, of Decatur, Illinois, reviewed the five cases and to them he added eight, with their case histories.

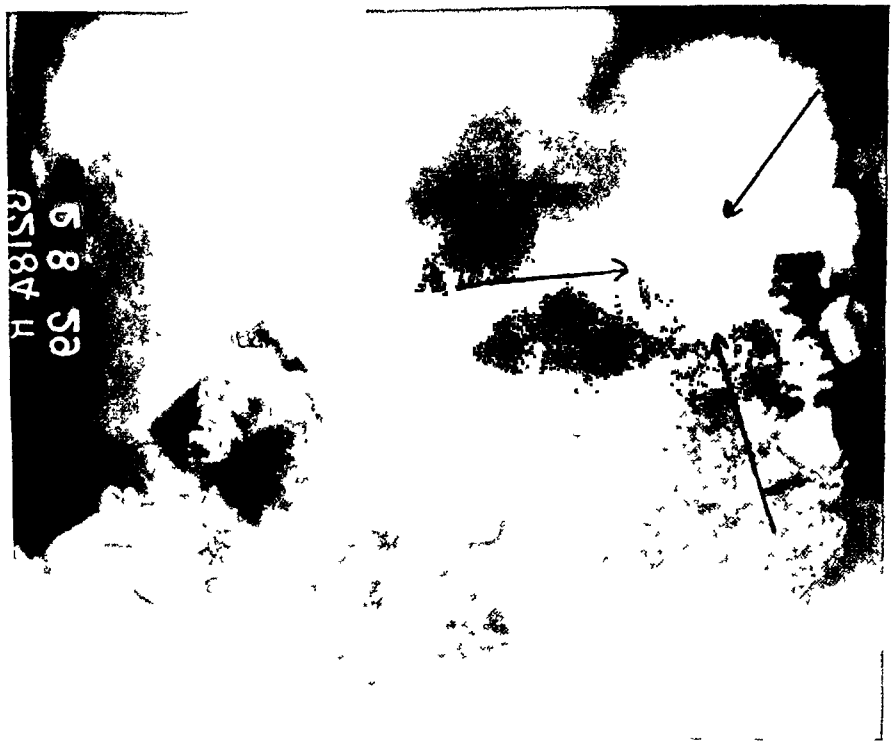


Fig 1. Negative shadow in lower part of stomach where mass displaces the barium meal

Since his report five others have been recorded, not including the one I am reporting at this time.

The mode of formation is not definitely known, but it has been suggested by Porter and McKinney that in cases due to the eating of persimmons the high percentage of

[1]Read before the Radiological Society of North America at the Fifteenth Annual Meeting, at Toronto, Ont., Canada, Dec 2–6, 1929.

gums and pectin was responsible. The persimmon contains 14.1 per cent gum and 7 per cent pectin.

The trichobezoar and trichophytobezoar are evidently formed gradually by more material being added from time to time. The phytobezoar, however, seems to be formed at one meal and remains in the stomach without becoming any larger.



Fig. 2. Negative shadow just below the gas bubble, the mass having floated to this position.

The symptoms are those of a severe gastro-enteritis occurring soon after eating or a few hours later, though in some cases not occurring until a day or two later. After the acute symptoms have subsided the patient may feel fairly comfortable, but rarely returns completely to normal: there may be some pain in the epigastric region or referred to the groin or kidney region, a sense of fullness or distress in the epigastrium, and other symptoms simulating gastric ulcer or gall-bladder disease. Usually there is not much loss of weight, in spite of the fact that the condition may have existed for weeks, months, or even years.

In the diagnosis, a carefully taken history is important. On examination, there may be detected in the epigastric region a freely movable tumor which is not tender on pressure and which may change its location upon changes of the position of the patient. The blood, urine, and gastric analyses are not affected in uncomplicated cases.

When a barium meal is given with the patient erect, a negative shadow or apparent filling defect will be noted in the most dependent portion of the stomach, and when a sufficient quantity of the meal has been taken the filling defect will change position by floating to the top of the fluid and resting just under the gas bubble. By placing

the patient on the table with the hips elevated the mass can be floated toward the pylorus.

Mistaken diagnoses have been common. A phytobezoar has been diagnosed as floating kidney, carcinoma, gastric ulcer, tumor of the stomach, hair-ball, movable spleen, polyp, and adenoma. In one case reported by Hart, three series of X-ray examinations did not reveal the phytobezoar and the surgeon did not find it while doing a gastroenterostomy on the patient. Later this patient developed an obstruction of the small intestine caused by the phytobezoar passing through the opening made by the gastroenterostomy and becoming lodged a short distance beyond it.

Gastric ulcer was found in two of Hart's cases and in our own case, the ulcer in each apparently having existed before the phytobezoar was formed. These food-balls may be multiple, as is shown in another of Hart's cases, in which a phytobezoar was found in the stomach and another—a smaller one—near the ileocecal valve, causing obstruction of the small intestine.

The treatment is essentially surgical, although other methods have been tried.

In the case of Mills and Simpson, reported by Hart, hydrochloric acid was given on account of achylia gastrica, and, a few days later, hard, dark masses were passed in the stools. In the case reported by Outten, manipulation and breaking down of the mass was accomplished. The giving of hydrochloric acid probably will not be successful in the majority of cases, because most of them have a high or normal acidity, and, on account of the frequency of gastric ulcer with phytobezoar and also the liability of intestinal obstruction being caused by these masses, I think the method of breaking them down by manipulation is contraindicated.

The surgical procedure consists in incision and removal in uncomplicated cases; in those showing gastric ulcer the ulcer is excised and the phytobezoar removed through this opening. The surgeon must bear in mind that with the patient on the operating table the mass is liable to be found in the cardiac end of the stomach, and also that multiple masses may be present.

CASE REPORT

Case 1. Mr. A. N., aged 57, laborer, patient of Dr. W. F. Cowan, Stevens Point, Wisconsin, and Dr. K. W. Doege, Marshfield, Wisconsin, was referred for roentgenologic examination, with a history of having had, for three weeks, severe intermittent cramp-like pains in the epigastric re-

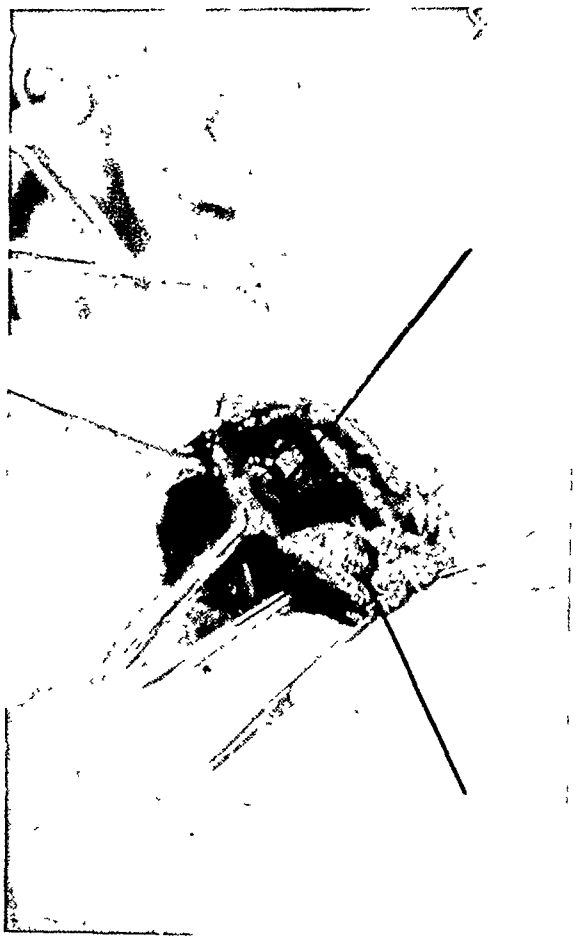


Fig. 3. Ulcer partly excised, its crater showing at the bottom of the picture. The phytobezoar is seen in the stomach.

gion and a constant feeling of fulness and distress, with belching of sour liquid but no vomiting. He had a poor appetite and had lost some weight. Chemical analysis showed free hydrochloric acid 47, total acidity 64.

Roentgenologic examination with the

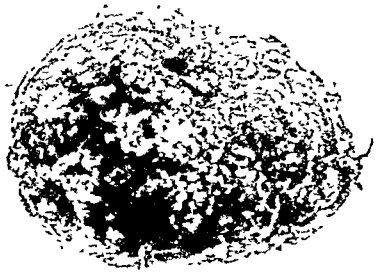


Fig. 4. Phytobezoar (about size of a lemon) after its removal.

screen and a barium meal on February 7, 1929, revealed a large filling defect in the antrum. As more barium meal was given the apparent filling defect was seen to move toward the upper part of the stomach, remaining just below the gas bubble. The patient was then placed on the table with the feet elevated and the head lowered, and in this way we were able to float the mass back to the pyloric end of the stomach. A large ulcer was also found on the lesser curvature. We could not obtain a definite history of the time of onset or the article of food which was responsible for the phytobezoar.

A roentgenologic diagnosis of large gastric ulcer and phytobezoar was made and on February 11th the patient was operated upon by Dr. K. W. Doege, the ulcer excised, and the phytobezoar removed through the opening made by the excision of the ulcer.[2] The mass was nearly round, black in color; weight 61.5 grams; circumference 18 centimeters. The crater of the ulcer was 2½ centimeters in diameter. The patient's recovery was uneventful.

CASES REPORTED SINCE 1923

Case 2. Clinic of Dr. Joseph W. Larimore, Barnes Hospital, Washington University Medical School, St. Louis, Mo. Female, aged 46, widowed. Chronic indigestion for eight months. Symptoms were like those of gallstone colic, but the gall bladder had been removed. Diagnosed by X-ray as benign adenoma. Operation: removal of phytobezoar, 5 by 3 centimeters.

Case 3. Clinic of Dr. Joseph W. Larimore. Male, aged 20, single, miner. Distress for twelve months, coming on after eating persimmons while on hunting expedition. X-ray revealed movable tumor size of lemon. Symptoms were like those in duodenal ulcer.

Case 4. Patient of Dr. D. L. Garrett, Tulsa, Okla., male, aged 42, fishing-rod maker. Had eaten freely of persimmons eight months previously. Operation on June 17, 1927. Phytobezoar, 9.5 by 4.2 centimeters, weight 68 grams.

Case 5. Patient of Dr. William B. Porter and Dr. J. T. McKinney, of Roanoke, Va., male, aged 35. Admitted on December 18, 1925. Gastric symptoms for thirteen months. Said that while hunting he had eaten freely of persimmons. He became sick and nauseated a few hours later, vomited, but did not vomit any of the persimmons. X-ray examination showed negative shadow in stomach. Phytobezoar diagnosed. Operation on December 24, 1925. Phytobezoar, weight 59 grams.

[2] About 120 feet of 16 mm. moving picture film was shown when this paper was read. The film was made up of the X-ray films, showing the ulcer and movable mass in the stomach, the important steps in the operation—the stomach laid open, the excision of the ulcer, and the removal of the phytobezoar, as well as the specimens after their removal.

Case 6. Patient of Dr. W. O. Upson, Battle Creek Sanatorium, Battle Creek, Mich., Mr. W., aged 42, farmer. Gastric distress for four or five years; attacks recently increased in frequency and severity. Roentgenologic diagnosis was a free tumor in the stomach. Operated on by Dr. J. T. Case. Bezoar (two inches in greatest length) removed. This patient was an inveterate tobacco-chewer. The specimen was examined by Dr. Francis Carter Wood, who claims to have found a persimmon seed in the center.

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DISCUSSION

Dr. H. B. Podlasky (Milwaukee, Wisc.): I want to show some slides of a phytobezoar case, a persimmon-seed tumor, adding another to those reported in the literature. In the Spring of 1929, Dr. Potter presented his case of persimmon-seed tumor, the same one he showed us to-day. I wish to acknowledge my debt to him for having been able in my own work to recognize a case of this type.

The patient I examined was referred to me by Dr. A. J. Patek, of Milwaukee, in the Fall of 1929. Arriving in the office at a period in which I usually make my fluoroscopic examinations, I was asked by my assistant to view some films which had been made of the stomach in this case at the morning examination.

It is rather strange how the mind is impressed or tricked into remembering some one or two factors which are helpful in directing one along the right path to a diagnosis. Dr. Potter's and Dr. Hart's descriptions of the shifting character of the stomach defect caused by this tumor had impressed themselves upon me as probably the most significant finding by which one first becomes aware of the possible presence of such a condition as here reported.

Dr. Hart and Dr. Potter state that the tumor mass can be made to shift or float about in the stomach while making the fluoroscopic examination. Having first observed the shifting character of the stomach defect in the films on my case, I made special preparation for the screen examination by taking a longer period than usual to prepare my eyes for visualization of the screen image. I confess I am not as keen as most in screen examinations. In spite of the preparation just referred to, I failed in recognizing the defect with the same ease on the screen as I had done when I briefly viewed the films. This may be a point to bear in mind and may account for the rather infrequent reports of this type of case from the southern part of this country where persimmons are frequently eaten.

Dr. W. E. Hart, of Decatur, Illinois, reported eight cases of this type in 1923, his article appearing in the *Journal of the American Medical Association* (Dec. 1, 1923, LXXXI, 1870). He states that the tumor mass is usually found in the antral area at

the beginning of the examination, but can later be made to shift or float. My slides will show the antral defect changing, however, in size and shape. [Four slides were shown.]

My patient left Milwaukee and was reexamined and operated upon at the Mayo Clinic. I have a letter from Dr. Kirklin with me stating that the mass removed was a persimmon tumor. This case, then, is the twentieth of this type to be reported. About four years ago the patient complained of symptoms referable to the gastro-intestinal tract; two years ago he was operated upon and gallstones were removed from the gall bladder.

In reference to differential diagnosis, it is important to obtain a history of persimmon ingestion. Roentgenologically, the defect in the stomach differs from that produced by cancer. In phytobezoar, the defect does not remain constant as to size, shape, and position, as in cancer. My patient was 42 years of age, a well nourished male of athletic proportions. There was no loss of weight, as you would expect to find in cancer, nor was there any tenderness to pressure over the stomach. Even in tumors of the stomach such as fibroma, angioma, and papilloma, the filling defects produced are much more constant than those produced by phytobezoar.

DR. J. D. CAMP (Rochester, Minn.): I was fortunate enough to screen the patient whom Dr. Podlasky has discussed, when he came to the Clinic. The screen findings corresponded exactly with the defects which Dr. Podlasky has shown in the slides. Something was said about a question of there being two tumors. I think that can be explained by the fact that the surgeon broke the tumor in delivering it from the stomach. Of course, the single mass readily accounts for the defect which Dr. Podlasky has shown.

DR. POTTER (closing): Dr. LeWald has discussed the subject of hair-balls, a great number of which have been found. He cited the case of a very brilliant woman in England who had several operations for the removable of recurrent hair-ball, occurring about one year apart. We have a very large hair-ball, about the size of the one shown by Dr. LeWald at one of the former meetings. This was removed from a woman's stomach about twenty-seven years ago, before the use of the X-ray in Marshfield.

Many laboratory rats and mice have hair-balls. Some are single but many are multiple, accounted for by the fact that the hair which the animals shed becomes mixed with the food on the floor of their cages and thus finds its way to the stomach.

An important point which I wish to emphasize, and which I believe will help to differentiate between hair-ball and food-ball, is that the food-ball will float, but the hair-ball will not.

The films shown by Dr. Podlasky reveal multiple negative shadows, indicating that the mass had been broken up before his examination. It is in such a case that intestinal obstruction may occur, caused by one of these small masses becoming lodged at some point in the small intestine.

I neglected to state that in our case the surgeon referring the patient for X-ray examination said that he thought he could palpate a mass in the epigastrium, but that it was only for an instant. When opening the stomach, the surgeon should thoroughly investigate the upper portion. One writer has suggested that the stomach should be opened wide enough to admit the hand.

X-RAY THERAPY IN THE TREATMENT OF ACUTE GONORRHEAL ARTHRITIS[1]

By IRA I. KAPLAN, B.S., M.D., Attending Radiation Therapist, Bellevue and Beth Israel Hospitals, NEW YORK CITY

From the Urological Service, Dr. A. R. Stevens, Director, and the Radiation Service, Bellevue Hospital, New York City

IN a large general hospital such as Bellevue, the Radiation Therapy Department is often called upon to assist in the treatment of lesions usually cared for otherwise. Among the very large number of gonorrheal patients admitted to the urological service at Bellevue, there are many suffering from extra-genital lesions. Quite frequently this takes the form of arthritis of one or more joints. Chetwood (1) states that gonorrheal rheumatism is the most important complication. Often it is for the relief of this symptom that the patient enters the hospital, and it is because the usual methods of treatment have failed in relieving these patients that the radiation therapist is called upon for aid.

Radiation therapy has been used with beneficial results in inflammatory lesions, and has proved very efficacious for tuberculous joint conditions. At the recent International Congress of Radiology, in Stockholm, good results were reported in the treatment of arthritic joint conditions by radiation. Although text-books on urology such as Young's, Lowsley's, or Chetwood's make no mention of radiation therapy for the treatment of gonorrheal arthritis, Wetterer (2), in 1921, reported treating such a case by X-rays with good results, and Guhrauer (3), in 1927, reported 23 such cases treated by him with good results. Grauer (4) reported good results in six cases of arthritis treated with roentgen rays. Sordello (6) has reported excellent results in six cases treated by mild doses of X-rays. He has stated, too, that treatment of one of the affected joints caused a recession of the symptoms in other joints. Good results were likewise reported with this therapy by Schulte (5) in April, 1927.

The patients referred to us were those with acutely swollen and excruciatingly painful joints. The result of treatment with radiation could be readily noted, the sedative effect usually occurring within twenty-four hours. In cases in which relief was obtained, the results were gratifying and fully justified the further use of this form of therapy.

Whatever may be the explanation of the action of radiation on normal and pathological tissues (and numerous suggestions have been offered), its action on inflammatory tissues requires a different explanation. Hyperemia and lymphocytosis do not sufficiently account for the reaction. Since the condition is not one which lends itself to autopsy or detailed microscopic examination, we must rely mainly on clinical observations.

We find that therapeutic X-radiation in the usual dosage does not destroy normal tissue, and, while a large dose of radiation will clinically increase the inflammatory process, a properly administered dose apparently retards further inflammatory growth and brings the process to a more rapid resolution. This we know, that direct action of radiation on the bacterial agent in the inflammatory area has been disproved.

Colwell and Russ (7) have shown that the common pathological forms appear to be highly resistant to X-rays, and they

[1]Read before the Radiological Society of North America at the Fourteenth Annual Meeting, at Chicago, December 3–7, 1928.

quote Murphy and Ellis to the effect that the resistance to bacterial infection by the body is increased by X-rays. This result they attribute to the action of the rays upon the lymphocyte-forming tissues. Gonococci evidently are insensitive to radiation in normal therapeutic doses, but the reaction on the tissues affected may be the production of some sort of bactericidal action or contrabacterial action, causing a cessation of the inflammatory process. Such action may result from the reaction of the lymphocytic tissue of the synovial membrane to the X-rays. Pordes (8) believes that X-rays have a selective action on white cells. However the action or reaction to radiation may be explained, clinically there is a remarkable subsidence of the acute symptoms and relief is rapid and permanent. The radiation, as given, does not cause fibrosis or any material change in the joint.

During the past year we have treated 68 cases (62 males and 6 females); of these, 26 complained of single joint involvement, and 42 of involvement of more than one joint. There were 65 white and 3 Negro patients. Of these cases, 52 had received treatment before being submitted to radiation. The joint most frequently involved in the series of cases treated by us was the knee. Of these cases, in 37 the knee alone was involved, and in 4 cases the elbow alone. The oldest patient was 53 years of age and the youngest was 17. In cases in which multiple lesions were present, three areas were treated at one session. In 17 cases, but one treatment was given to relieve the condition.

The technic used was high voltage X-rays, with filtration of 0.5 millimeter copper and 1 millimeter aluminum. The target distance was usually 30 centimeters, and the size of the field treated 9 × 12. Most frequently 25 per cent of the skin erythema dose was given to each area, but in cases in which multiple lesions were treated at one session a 20 per cent dose of the skin erythema on each area was administered. While most cases reacted well on the first treatment, several received two or more subsequent treatments before complete relief was obtained. The knee and elbow involvements reacted more quickly than did the lesions of the smaller joints.

While X-rays used therapeutically are not being suggested here as a panacea in joint diseases, in acute and refractive gonorrheal arthritis they have, with us, proved quite efficacious in relieving the acute symptoms of the lesion, and not infrequently in bringing about permanent relief. The results occur early. Radiation therapy may be used either alone or in conjunction with the usual methods of treatment. There are no contra-indications to the use of this form of therapy.

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CASE REPORTS AND NEW DEVICES

BRAIN ABSCESS FROM WELCH BACILLUS INFECTION

CASE REPORT

By V. W. MAXWELL, M.D., JACKSON, MISSISSIPPI

Patient, a white boy, aged 17 years, was struck on the head in the right parietal region by the sharp end of a file. The injury inflicted was thought at the time to be a very small scalp wound. Five days later a paralysis of the left arm and leg was noted. At the same time a mild convulsion developed. X-ray films made of the patient's head at this time in the anterior-posterior and lateral positions revealed the abscess, as shown in Figures 1 and 2. An operation done over this portion of the skull revealed a large amount of pus and gas, which spurted out when the skin flap was turned back. In trephining the skull at this point a large amount of pus and gas escaped from the dura. The pus, on being cultured, showed prompt growth of the bacillus of Welch. The patient died two days later without having regained consciousness.



Fig. 1. Lateral view, showing abscess.



Fig. 2. Anterior-posterior view, five days after injury.

A MILLIAMPERE MINUTE DOSE TABLE FOR SUPERFICIAL THERAPY

By I. S. TROSTLER, M.D., F.A.C.R., F.A.C.P., CHICAGO

Having been asked five times within the last month for a safe dose table for skin and superficial roentgen therapy, and thinking that others may find such a table useful, I herewith offer the one which I have worked out and have used for several years.

VOLTAGE		FILTRATION				
Kilovolts peak	Spark gap (blunt points)	Unfiltered	0.5 mm. Al	1.0 mm. Al	2.0 mm. Al	3.0 mm. Al
68	3 inches	40 ma./min.	72 ma./min.	95 ma./min.		
78	4 inches	30 ma./min.	50 ma./min.	70 ma./min.		
90	5 inches	26 ma./min	40 ma./min.	54 ma./min.		
100	6 inches	20 ma min	30 ma./min.	40 ma./min.	60 ma./min.	75 ma./min.
112	7 inches	18 ma min	24 ma./min.	32 ma./min.	48 ma./min.	60 ma./min.
125	8 inches	15 ma min	21 ma./min.	27 ma./min.	38 ma./min.	45 ma./min

The doses are for the average skin, and have all been proven safe. For light blondes and thin-skinned types, 75 per cent (or less) of the doses given should be applied.

More than one unfiltered dose should never be applied to any one skin area.

The dosage given will produce one skin unit (epilation) at 40 cm. (16 inches) anode skin distance.

DEFECTS IN MEMBRANOUS BONES, EXOPHTHALMOS, AND DIABETES INSIPIDUS ("CHRISTIAN'S" SYNDROME)

CASE REPORT

By T. P. ROTHNEM, M.D., FARGO, NORTH DAKOTA

The following case is reported because of the rarity of this condition, and that the conclusions from pathological reports be considered with reservation when this syndrome is present.

D. F., a boy aged two years, came under our observation, February 20, 1925. He complained of a painful shoulder which had been giving him distress for a week. The pain radiated down the arm to the end of the fingers. A swelling had been noticed at the back of the shoulder a few days before. The family history gave no evidence of tuberculosis or syphilis. The child had not had any of the usual diseases of childhood, nor was there any history of former injury.

Physical examination showed a fairly well-nourished child, but somewhat pale. Head, neck, and cardio-respiratory region negative. Over the left scapula there was a



Fig. 1. Several irregular lesions varying in size, the largest one being in the left temporal region.

circumscribed swelling, with tenderness, heat, and fluctuation. The child refused to abduct the arm. The abdomen seemed rather large, with visible superficial veins: no abnormal palpable findings. The lumbar region was covered with a papular and erythematous rash. The limbs appeared normal.

Laboratory findings: Urine negative; hemoglobin 45 per cent; red cell count 4,000,000; white cell count ranging between 13,350 and 23,500; polynuclear neutrophiles 58 per cent; small lymphocytes 27 per cent, and large mononuclear 3 per cent; eosinophiles 1 per cent; Wassermann test negative; Bence-Jones protein test negative.

Radiographic study of the skeleton at various times revealed extensive defects in the skull bones, left scapula, ribs, lower end of humerus, and middle third of shaft of left femur. The scapula and skull showed the most extensive and progressive involvement (Figs. 1, 2, 3). The lungs appeared normal at all times.

A few days after the first examination, an incision was made over the dorsal part of the left scapula. This was curetted and a specimen of tissue sent to the University of North Dakota Public Health Laboratory, the report of the pathologist being "tuberculous granulation tissue." Seven months later a biopsy was made, removing tissue from one of the fluctuating areas in the skull. This specimen was sent to the pathologist at the University of Minnesota, the report stating the tissue to be that of giant-cell tumor.

We decided to report the case to the Registrar of the National Committee on Bone Sarcoma. The opinions and diagnoses of the three pathologists on the Registry are as follows:

CASE NO. 697, D. F.

(1) "In spite of Dr. B.'s histologic opinion, the location of these lesions, their multiplicity, the cortical involvement in their neighborhood, and the gross description, make me feel that the lesion is a low grade inflammation, probably tuberculosis or syphilis."

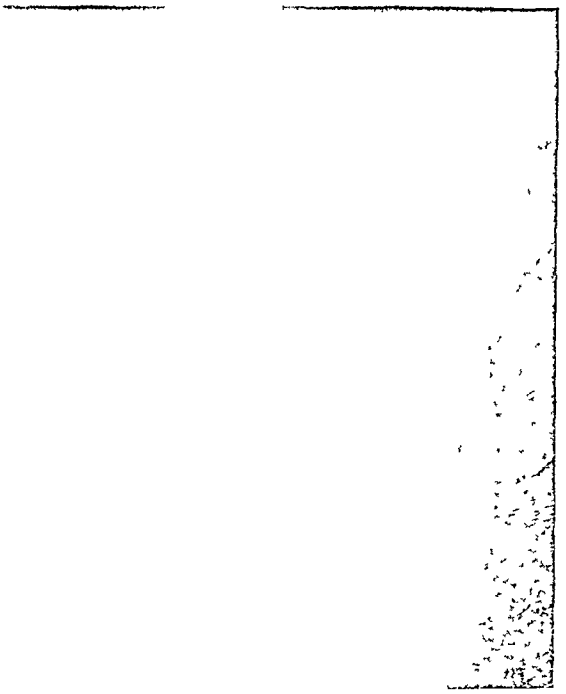


Fig. 2. The lungs appear normal. The left scapula shows extensive involvement

(2) "Multiple infectious lesions; would suspect syphilis."

(3) "Multiple infectious lesion."

Seven months after the onset, the child developed a marked exophthalmos of the right eye. This persisted to a variable degree throughout the disease, and, in February, 1926, the exophthalmos became very pronounced. The child suffered considerably from the eczematous condition of the lumbar region which had now extended towards the shoulders, and over the abdomen and anterior chest (Fig. 4).

After a month's treatment with roentgen irradiation, the skin condition disappeared. Roentgen irradiation was also given to the different areas of bone involvement, and in June, 1926, the mother stated that at times the exophthalmos would disappear. The

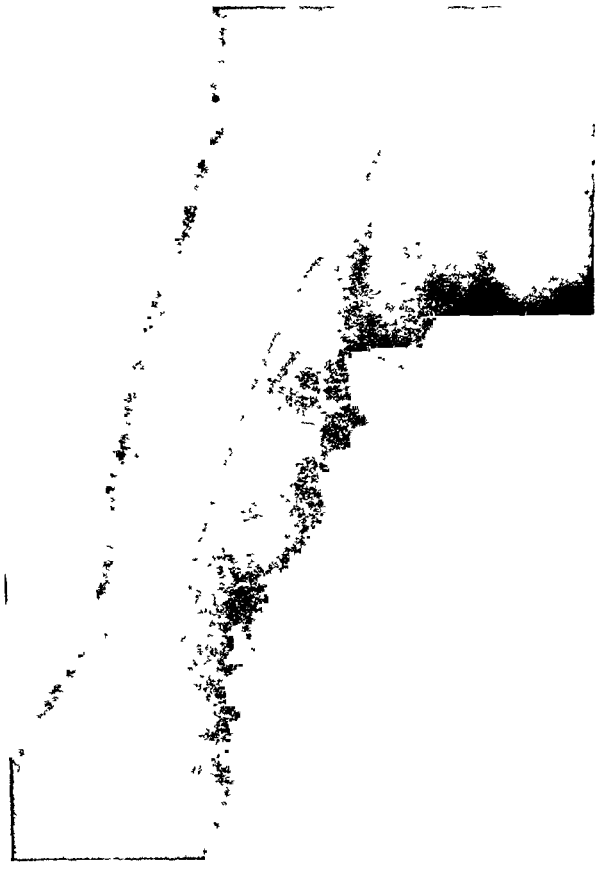


Fig. 3. The middle third of shaft has a medullary porosity, with sclerosis of cortical tissue.



Fig. 4. The eczematous, papular, and pustular condition of the back, and the post-operative scar over the left scapula.

radiographs at this time also showed evidence of increased bone density at the irregular margins in the skull lesions—likely an attempt at bone repair.

The information was later obtained that the child drank a large amount of water and would often urinate about every hour, the mother expressing her belief that the large abdomen was due to the excessive water-drinking. The boy was fairly active most of the time and not confined to bed. In March, 1927, he died suddenly without any apparent illness, having the previous day been playing about. Autopsy was not permitted.

The pathological reports from five pathologists varied, the predominating opinion being that it was a chronic inflammatory process. The presence of giant cells in considerable numbers was undoubtedly a factor. In this case we had also an involvement of the middle third of the shaft of the left femur, and giant-cell tumors have not been found in the shafts of long bones. Besides, there was considerable cortical bone thickening. Rowland, in his summary of reported cases, also mentions the numerous multinuclear giant cells present, but states that the chief characteristic feature is the presence of a large amount of lipoid in the cells. He considers this condition as "a generalized xanthomatosis, representing pathologic lipoid storage, or lipoid cell hyperplasia of the reticulo-endothelial system."

The clinical and anatomical findings in this case are in every respect so similar to those classified under the description of Christian's syndrome that it is deemed justifiable to place this in the same category.

THE TRACING OF FILMS TO REDUCE THE FIRE HAZARD

By M. A. LOEBELL, M.D., Bethesda Hospital, Zanesville, Ohio

We have been besieged during the past year by inspectors with suggestions for the storage of X-ray films, ranging from bomb-proof vaults twenty feet underground and a half-mile distant from the hospital, to concrete vaults on the roof of the institution, where, in addition to films, ether and other inflammable material must be stored.

The only films which need to be preserved, except the few for teaching purposes, are such as may be of medico-legal importance; all others may be destroyed as soon as the radiologist has rendered a written report.

To reduce the fire hazard in our hospital and private laboratory we have instituted the following procedure, which has proven very satisfactory to our surgical staff and acceptable in our local courts. It reduces the number of films which must be preserved, taking care of fractures, separations, filling defects, delineation of the bony structures, and others which will occur to the roentgenologist.

Tracings of radiographs are made upon transparent (onion-skin) paper in the following manner: An ordinary illuminating box is tilted at a convenient angle; film overlaid by paper is fastened under a clip. With pencil or pen, follow the outline of a sufficient portion of the subject to identify the structure, carefully outlining fractured ends and fragments. The radiologist point-

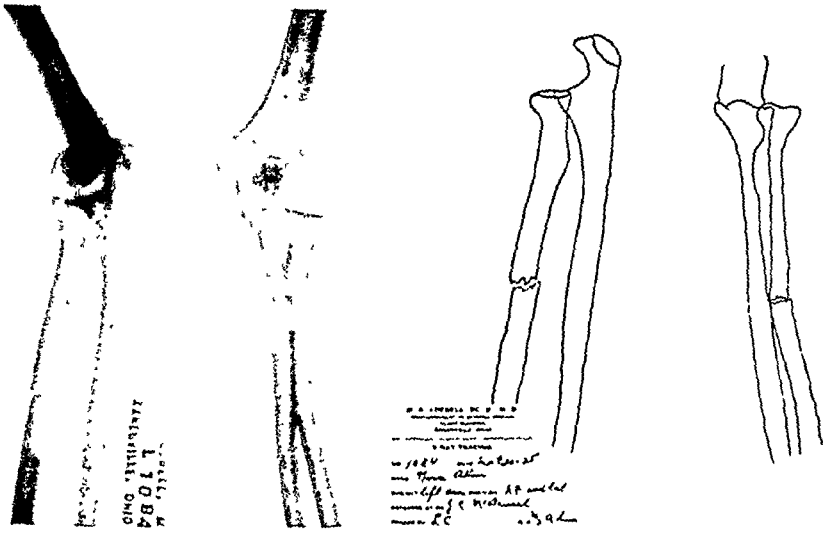


Fig. 1. Example of film of fracture and the tracing made from it.

ing out the essential outline, any office or laboratory assistant, without special training, can make a good tracing in a short time. Occasionally, with poor negatives, it is necessary to retouch portions of the outline of the radiograph with a soft pencil to make tracing easier and more accurate.

At the hospital, tracings are initialed by the assistant, O. K.'d by the roentgenologist, and filed with the patients' hospital records. In our private practice a copy is sent to the physician or surgeon referring the case.

To laymen and others unaccustomed to reading radiographs, tracings present much clearer pictures than negatives. The speed, safety, accuracy, simplicity, and economy of this method are quite apparent.

EDITORIAL

M. J. HUBENY, M.D. *Editor*
BENJAMIN H. ORNDOFF, M.D. . *Associate Editor*

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PROGRESS

From Galileo and Copernicus to Darwin and Helmholtz may seem like a long interval; these pioneers in science have left their footprints on the sands of time, faintly but indelibly. However, in the past score of years the sciences have developed so furiously and extensively as to influence every human activity, creating new intellectual frontiers whose bounds seem limitless and urge towards new goals and achievements.

The basic sciences have firmly established themselves in medicine, displacing sophistries with sound reasoning. Instruments of precision such as the thermometer, stethoscope, electrocardiograph, microscope, and spectroscope are necessary adjuncts.

When Roentgen made his wonderful discovery, another boon to humanity was born. Its cyclonic development was astounding. To-day its field of usefulness is not limited to medical diagnosis and the treatment of disease, but the chemist, the physicist, the biologist, and the industrialist have combined. Another milestone was reached by the patient efforts of the Curies, paralleling the importance of the X-rays. To harness these agents is the task of the present-day scientist, thereby making this a happier world in which to live.

Men with a common purpose of high ideals and a sense of responsibilities united themselves and organized the Radiological Society of North America. From a stripling to a fair sized adult in a decade and a half is not a bad growth record; however, not content with past attainments, but vigorous and restless, it is searching for further expansion and fields of usefulness. The allegiance of its members and the vision of its officers have created a substantial organization—not a nebulous body gradually losing momentum, eventually becoming impotent, with final disappearance. RADIOLOGY, the official Journal, symbolized the virility of its members; a consistent expansion occurred, and it is with justifiable pride that we think of the steadfast support of the members making this possible.

The present period of tumultuous research and unity of purpose was sensed by certain analytical minds and it became quite evident that some means of co-ordinating and disseminating knowledge concerned with the investigation and application of radiant energy would become necessary. Up to the present no such outlet has existed, no means of making known immediately the natural steps in experimental progress and practical use.

It was at this point that the Chemical Foundation was approached by these analytical minds and the needs explained. After thorough investigation and consideration RADIOLOGY was selected as the means of spreading the gospel of radiant energy. Just one year ago the officers of the Radiological Society of North America accepted the wonderful opportunity of making RADIOLOGY even more important than heretofore. Like all vital projects, the foundations, working plans, and details require the

utmost thought, for, once embarked upon a program, no retrenchment is possible.

Attention is called to the July issue, especially to its size, its articles, its editorial by Dr. George L. Clark, and to the personnel of the Editorial Staff. The latter is international in scope and represents recognized authorities, covering all phases of investigation and application of radiant energy, assuring the readers of the most advanced and reliable data. Especial attention will be given in future issues to the cancer problem as it relates to radiology.

How was this development made possible? It is usual for scientific bodies to be limited financially, and, while this Society was on a sound financial basis, nevertheless expansion was possible only up to a given point. The generosity of the Chemical Foundation makes it possible to enlarge any issue in accordance with the amount of material on hand, without additional expense to the Society. It grants the essayists all the cuts necessary without charge. It gives each author 100 reprints gratis. It graciously creates a fund to remunerate abstractors whose efforts were heretofore wholly voluntary and whose sustained help is appreciated by the Editorial Department. It assures the Society that any deficit created by the editing and printing of the official Journal, RADIOLOGY, will be taken care of by the Chemical Foundation, which will reimburse the Society at the end of each quarterly period, at which time a statement will be issued to the Chemical Foundation by the Radiological Society of North America.

What does the Chemical Foundation get? *Nothing.*

It has nothing to do with the running of the Journal; it cannot control the editorial policy; it cannot control the financial policy. All it asks is the printing of acceptable articles relating to radiant energy, whether medical, physical, chemical, biophysical, or biochemical in nature, also industrial researches and their application.

What does the Chemical Foundation expect in return? For itself—*nothing.*

Should the Journal make a profit, the Chemical Foundation expressly states that this profit shall be expended for research in radiology under the direction of the Radiological Society of North America.

This co-operation and magnanimity are fruitful of great good. Will each reader of this article help in making RADIOLOGY a more potent factor in the radiological world? Will you contribute your mite, directly or indirectly? Will you stimulate the interests of our fellow-workers—the chemists, physicists, physiologists, biologists, and research workers—to help us? We extend to these and all others interested in the allied sciences an invitation to enter our fold of contributors. There is no line of cleavage—animate substances are derived from inanimate substances; the search for life and its phenomena still continues.

THE AMERICAN JOURNAL OF CANCER

The American Journal of Cancer, which will make its first appearance in January, 1931, will be not merely a continuation of the former *Journal of Cancer Research* but will represent a far wider field. It will continue to present the original papers on experimental work which established the earlier journal on such a sound scientific basis and will add to these, clinical contributions representative of the best opinion and practice both in America and abroad. Photographs, microphotographs, drawings, diagrams, and color plates will supplement the articles and add not alone to the beauty of the page but to the clarity and elucidation of the text.

One of the important new features of the Journal will be a complete abstract service covering the subject of cancer in all its phases and relationships, not only with the various branches of purely medical science—pathology, gynecology, dermatology, urology, neurology, surgery, etc., but also with chemistry, general biology, and genetics; the statistical, educational, and public health aspects will also be covered.

It is planned to make this abstract service a comprehensive survey of the world's literature so that within the pages of a single periodical the subscriber will have, issue by issue, the results of work being done not only in our own country but in Great Britain and the Continent, the clinics and schools of South America, Australia, South Africa, and the medical centers of China, Japan, and India. More than five hundred journals will be reviewed for this service as well as the reports of various Cancer Commissions and societies.

Editorial comment on the abstracted material will be offered as occasion arises and authors whose work is reviewed will be given opportunity of replying to any criticism or questions that are raised in connection with their work, so that the Journal will be truly representative of all schools.

Clinical reports from the Memorial Hospital, book reviews, editorials, and various other features will be included.

The Journal will, of course, remain on the highest scientific basis, and, while its appeal will be wide enough to include the general practitioner as well as the most highly specialized research worker, no attempt will be made to "popularize" it in the commonly accepted sense of that term.

Dr. Francis Carter Wood, as Editor, has associated with himself an editorial staff whose names are at once a guarantee of the high standing of the Journal and of its wide scope. These include:

Surgery
Alan M. Dowling
Robert E. Fitzgerald
Dallas B. Phemister
Allen Whipple
Frank H. Lahey
Thomas H. Cryer
George David Stewart

Gynecology
Howard C. Taylor
Charles C. Norris

Urology
J. Bentley Squier

Dermatology
Marion B. Sulzberger
William Allen Pusey
George Miller Mackee

Pathology
James Ewing
Alfred Scott Warthin
William Ophüls
H. E. Robertson

Surgical Pathology
Joseph C. Bloodgood

Experimental Pathology
William H. Woglom
Warren T. Simpson
Leo Loeb

Chemistry
H. Gideon Wells

General Biology
Edwin G. Conklin

Bacteriology
Hans Zinsser

Genetics
Thomas H. Morgan

Radiology
Maximilian J. Hubeny

Statistics
Edwin B. Wilson

Education
Clarence C. Little

Public Health
George H. Bigelow
Amber M. Stimson

The American Journal of Cancer will continue to be published from the Institute of Cancer Research, Columbia University, quarterly at first, with the possibility of more frequent publication as the amount of material justifies. Its formation will be attractive and practical. Clear, readable type, good paper, well proportioned pages, and beautiful illustrations in color and black and white will make it a model of periodical manufacturing.

CANCER
"American Journal of Cancer"
"Radiology"

The universal scourge is receiving more attention now than ever; great efforts are being made to ameliorate or cure this pest. Researches are being made throughout the world; these investigations are clinical, therapeutical, biophysical, biochemical, and pathological in nature.

Do you wish to be abreast of the times? If so, a combined subscription to the *American Journal of Cancer* and RADIOLOGY to members of the Society can be had for $8.00; by non-members these two journals can be obtained for $9.00. Possession of these two will assure you of all facts and data as soon as they are available.

RATES TO THE ANNUAL MEETING

Because the all-year tourist rate to California prevails over all other rates, the Transcontinental Passenger Association has declined to make a rate of one and one-half fare for the round trip for the Los Angeles meeting. This notification reached me too late to be published in the November issue.

I. S. TROSTLER, M.D.

ROENTGENOLOGICAL CONFERENCE

BALTIMORE, FEB. 6 AND 7, 1931

The roentgenologists of Baltimore issue a cordial invitation to other roentgenologists to attend a conference in their city on February 6 and 7, 1931. The Lord Baltimore Hotel will be the headquarters of the meeting, and it is hoped that all those attending will stay at this hotel because bus transportation will be furnished to and from the different meeting places.

It is contemplated having the opening session at the Johns Hopkins Hospital, Friday morning at 9 o'clock, and the afternoon session at the University of Maryland Hospital. Some entertainment will be provided for Friday night. Saturday the scientific session will be held at the Mercy Hospital. The Staff of the Howard A. Kelly Hospital will conduct a conference on roentgen and radium therapy.

It has been a long time since the Baltimore roentgenologists have held a conference and they hope many will find it possible to attend.

CHARLES A. WATERS, M.D., *Chairman,*
1100 North Charles Street,
HENRY J. WALTON, M.D., *Secretary,*
104 West Madison Street,
JOHN W. PIERSON, *Treasurer,*
1107 St. Paul Street.

DR. J. C. BLOODGOOD'S CLINICS AT THE LOS ANGELES MEETING

Pursuant to Dr. Bloodgood's "Invitation to Radiologists," in the September issue of RADIOLOGY (page 403), two clinics will be held by Dr. Bloodgood, to which each physician attending the Los Angeles meeting may bring a lantern slide of a bone tumor case for interpretation. Wide announcement of these clinics has already been made, the present brief notice serving simply as a final reminder.

Dr. Bloodgood's clinics are always largely attended, and have proved of inestimable value to those who, through the medium of slides or films, have availed themselves of his advice.

CORRECTIONS

Attention is called to a correction in Dr. Webster W. Belden's discussion of the paper on Verruca Plantaris by Dr. J. Newton Sisk in the November issue (p. 565).

Beginning at the fifteenth line, it should read as follows: "We use the following technic: Shielding down carefully around the lesion with lead, we apply a 6-inch gap, 3 ma. of current, 2 min. exposure time, at an 8-inch distance."

Dr. George E. Pfahler wishes to state that, referring to his paper in the September issue, Figures 11 (page 348) and 13 (page 350) are transposed, the descriptive legend now accompanying Figure 11 rightfully referring to Figure 13 and the legend as printed with Figure 13 to be read as belonging with Figure 11.

A NEW DEPARTMENT OF RADIOLOGY

The September, 1930, issue of *Clinical Medicine and Surgery* marks the initiation of a new Department of Radiology, of which the Associate Editors are Henry Schmitz, M.D., F.A.C.S., F.A.C.R., and Wilbur H. Gilmore, M.D., both of Chicago

and both members of the Radiological Society of North America. The latter contributes a paper entitled "The Roentgenologist," in which he makes the following well-considered comments:

"A discussion of the position of the roentgenologist, in this advanced age of diagnostic medicine, would be trite, but the many laymen who have entered the technical side of roentgenology, who maintain so-called commercial X-ray laboratories, and who presume to advise medical men as to the proper interpretation of X-ray shadows, is so great that I feel it will not be amiss to attempt to differentiate between a graduate physician, skilled in the use of the X-rays, and a mere film-maker or technician.

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"Probably the source of most trouble in X-ray interpretation is the inherent tendency in all of us *to see entirely too much.*

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"When he intricate structure of the l the many variations whi all within normal limit and the logic changes which n occur ty to separate all the shadows o due to both normal and abnor ns of structures, is there that the man rendering the ser be medically trained?

here has been no t to present here scientific treati ave tried to give the viewpoint of t an who is trying to specialize in the honest use of the X-ray. It has been impossible to generalize on this discussion, but the points which have been raised are these, how can the roentgenologist individual render the service which the attending physician should receive and must have, if the man who pays the bill is to get what is due him?"

Dr. Schmitz contributes "An Outlook in Cancer Therapy," a brief paper, yet one full of concrete statements, among others, the following:

"These facts have been recognized by the American Society for the Control of Cancer and the American College of Surgeons. The societies are of the opinion that the treatment of cancer must be entrusted to those physicians who are equally well trained in the surgical technic of radical cancer eradication and in the application of radiation, either by seeds intratumorally, or by surface and distant radiation. Only thus can the cancer patient receive the benefits of either method of treatment, alone or in combination, according to standardized indications based on the location and extent and the histologic character of the growth."

ESSAYISTS ON THE PROGRAM OF THE ANNUAL MEETING

The following is an alphabetical list of the essayists on the program of the Annual Meeting, Los Angeles, Dec. 1 to 5, 1930.

1. Kenneth D. A. Allen, M.D., Denver
 "The Post-operative Behavior of the Diaphragm."
2. Emil G. Beck, M.D., Berkeley, California
 "Co-operation between Surgeon and Radiologist Essential to Effective Cancer Therapy."
3. David S. Beilin, M.D., Chicago
 "The Clinical Value of Oral Cholecystography."
4. Webster W. Belden, M.D., New York City
 "Further Observation of Osteitis Deformans."
5. Edward S. Blaine, M.D., Chicago
 "Another Case of Needle with Encrusted Stone in the Kidney."

6. Joseph C. Bloodgood, M.D., Baltimore
"Relative Merits of the Irregular Practitioner, Particularly in Relation to Cancer."
7. Arthur R. Bloom, M.D., and
W. L. Hull, M.D., Detroit
"Intravenous Pyelography in the Normal."
8. William R. Brooksher, Jr., M.D., Fort Smith, Arkansas
"Linitis Plastica."
10.[1] Samuel Brown, M.D., Cincinnati
Title to be announced later.
11. Thomas A. Burcham, M.D., Des Moines, Iowa
"Industrial Spines."
12. Montrose T. Burrows, M.D., Pasadena, California
"Clinical and Experimental Observations Relative to the Etiology of Cancer."
13. John D. Camp, M.D., Rochester, Minnesota
"A Roentgenologic Study of Pyloric and Pre-pyloric Deformities."
14. John R. Carty, M.D., New York City
"An X-ray Sign in the Diagnosis of Esophageal Orifice Hernia."
15. Henry A. Chapin, M.D., Jacksonville, Illinois
Title to be announced later.
16. George L. Clark, Ph.D., Urbana, Illinois
Titles of papers to be announced later.
17. L. G. Crosby, M.D., Denver
Title to be announced later.
18. Kenneth S. Davis, M.D., Los Angeles
"Atypical Bone Tumors, with a Presentation of Two Cases."
19. Jesse W. M. Du Mond, Ph.D., and Archer Hoyt, Ph.D., Pasadena, California
"Present Status of the Problem of Measurement of X-ray Intensity and Quality."
20. John Dunlop, M.D., and
Carl H. Parker, M.D., Pasadena, California
"The Treatment of Compressed and Impacted Fractures of the Bodies of the Vertebræ."
21. Maurice F. Dwyer, M.D., Seattle, Washington
"Gastric Tumors."
22. Leo Eloesser, M.D., San Francisco
"Congenital Cystic Disease of the Lung."
23. Edwin C. Ernst, M.D., St. Louis
Title to be announced later.
24. Frances A. Ford, M.D., Rochester, Minnesota
"Radiation Therapy in Functional Ovarian Disorders."
25. Leo H. Garland, M.D., San Francisco
N. E. Wayson, M.D., Honolulu, Hawaiian Islands, and
W. Edward Chamberlain, M.D., San Francisco
"The Bone and Joint Changes of Leprosy."
26. Roy G. Giles, M.D., Temple, Texas
"Radiotherapy in Myelogenous Leukemia."
27. Mark A. Glaser, M.D., Los Angeles
"Campiodol."
28. Otto Glasser, Ph.D., and
U. V. Portmann, M.D., Cleveland
"Gurwitch's Mitogenetic Radiation."
29. Thomas L. Gray, M.D., St. Thomas, Ont., Canada
"The Value of X-rays in Diagnosis."
30. Thomas A. Groover, M.D.,
Arthur C. Christie, M.D., and
E. A. Merritt, M.D., Washington, D. C.
"The Radiologist as a Consultant."
31. Joseph L. Harvey, M.D., Denver
"The Training of the X-ray Technician."

[1] R. Mark Brown, M.D., of Ogden, Utah, who was to have presented a paper, passed away Sept. 12, 1930.

32. Charles H. Heacock, M.D., Memphis, Tennessee
"Obstructive Lesions of the Small Bowel."
33. I. Seth Hirsch, M.D., New York City
Title to be announced later.
34. Fred Jenner Hodges, M.D., Madison, Wisconsin
"Lipiodol Studies of the Female Pelvic Organs."
35. C. C. Hopkirk, M.D., Santa Monica, California
"Observations in the Practice of Roentgenology in the Japanese Empire."
36. Harvey S. Hunsberger, M.D., San Francisco
"Adaptation of Technics to Individual Cases: Some Special Views that have Proven Valuable."
37. Leopold Jaches, M.D., New York City
Title to be announced later.
38. Minas Joannides, M.D., Chicago
"The Influence of the Diaphragm on Gastric Peristalsis."
39. Max Kahn, M.D., Baltimore
Title to be announced later.
40. Maurice I. Kaplan, M.D., Chicago
"Observations in Skull Injuries."
41. L. C. Kinney, M.D., San Diego, California
"Bone Changes in Buerger's Disease and Arteriosclerosis."
42. Carl E. Koenig, M.D., Seattle, Washington
"Pulmonary Tuberculosis in Children."
43. Ernest A. Kraft, M.D., Danville, Illinois
"Atypical Pleural Effusion."
44. John D. Lawson, M.D., Woodland, California
"Further Observations in the Use of High Milliamperage Technic."
45. Isaac Levin, M.D., New York City
"Proper Co-ordination between Surgery, Radium, and X-ray Therapy in Cancer of the Breast."
46. Burton J. Lee, M.D., New York City
Title to be announced later.
47. Lester Levyn, M.D., Buffalo, New York
"Cholecystography in the Late Months of Pregnancy."
48. James L. McKnight, M.D., Tucson, Arizona
"Tuberculosis of the Bowel, with Special Reference to X-ray Diagnosis."
49. H. E. Martin, M.D., and
Otto H. Pflueger, M.D., San Francisco
"Comparative Radiosensitivity of Epidermoid Carcinoma within Hypopharynx."
50. James M. Martin, M.D., Dallas, Texas
"Radiation Therapy of Malignant Lesions of the Mouth."
51. Leon J. Menville, M.D., New Orleans
"X-ray Study of the Passage of Various Foodstuffs through the Gastrointestinal Tract of Man."
52. Leon J. Menville, M.D., New Orleans
"The Lay Situation in Louisiana."
53. Louis A. Milkman, M.D., Scranton, Pennsylvania
"Pseudofractures—Multiple, Idiopathic, Progressive, and Symmetrical."
54. E. H. Newcomer, M.D.
N. B. Newcomer, M.D., and
C. A. Conyers, M.D., Denver
Title to be announced later.
55. Frederick W. O'Brien, M.D., Boston
"Unrecognized Vertebral Fracture *versus* Kummell's Disease."
56. Benjamin H. Orndoff, M.D., Chicago
"The Pathological Cervix: A Pre-cancerous Lesion."

57. C. C. Owen, M.D., San Bernardino, California
Title to be announced later.
58. Henry K. Pancoast, M.D., and
Eugene P. Pendergrass, M.D., Philadelphia
Title to be announced later.
59. Roy A. Payne, M.D., Portland, Oregon
"The Present Status of Appendiceal Diagnosis."
60. C. E. Piersall, M.D., Reno, Nevada
"Hypodermoliths."
61. Ernst A. Pohle, M.D., Ph.D.,
Gorton Ritchie, M.D., and
Cecil S. Wright, M.D., Madison, Wisconsin
"The Effect of Roentgen Rays on the Healing of Wounds."
62. Sidney A. Portis, M.D., Chicago
Title to be announced later.
63. R. P. Potter, M.D., Marshfield, Wisconsin
Title to be announced later.
64. D. T. Quigley, M.D., Omaha, Nebraska
"What shall we Teach the Public in Connection with Cancer and how shall we Present it?"
65. D. A. Rhinehart, M.D., Little Rock, Arkansas
"Air and Gas in the Tissues: A Radiological Study."
66. Charles M. Richards, M.D., San Jose, California
Title to be announced later.
67. Cassie B. Rose, M.D., Chicago
"X-ray Treatment of Bone Metastasis."
68. George S. Sharp, M.D., New York City
"Treatment of Maxillary Antrum Growths, with Special Reference to the Procedures Both Radiological and Surgical Depending upon the Degree of Advancement of the Growth."
69. William A. Shaw, M.D., Elko, Nevada
"Difficulties Confronting the Small Town X-ray Man."
70. Benjamin H. Sherman, M.D., Hollywood, California
"Pre- and Post-operative Treatment of Scar Tissue."
71. A. B. Smith, M.D., San Diego, California
"General Subject of 'Fed Meal' or Opaque Enema."
72. Robert S. Stone, M.D., San Francisco
"X-ray Findings in the Chests of Tuberculin-positive Children."
73. Henry Snure, M.D., Los Angeles
"Mediastinal Pleurisy."
74. Albert Soiland, M.D., Los Angeles
"An Adjunct in the Care and Treatment of Cancer."
75. J. V. Sparks, M.D., London, England
"Pulmonary Asbestosis."
76. Harold A. Spilman, M.D., and
E. T. Edgerly, M.D., Ottumwa, Iowa
"Pulmonary Tuberculosis."
77. Lorenzo L. Stephens, M.D., Seattle, Washington
"Epitheliomata of the Face and Head." (Illustrated by moving picture.)
78. Laurence R. Taussig, M.D., San Francisco
"A Lantern Slide Demonstration of Malignant Growths of the Skin and Their Treatment by Radium."
79. Henry J. Ullmann, M.D., Santa Barbara, California
Title to be announced later.
80. Harry M. Weber, M.D., Rochester, Minnesota
"Roentgenologic Manifestations of Tuberculosis in the Alimentary Tract."
81. William O. Weiskotten, M.D., San Diego, California
"Roentgen Diagnosis of Obstetrical Monsters."
82. Sanford Withers, M.D., Denver

"Admission of X-ray Plates as Court Evidence."

83. FRANCIS CARTER WOOD, M.D., New York City
"Palliative Radiotherapy of Malignant Growths."

84. GEORGE A. WYETH, M.D., New York City
"The Evolution and Present Status of Electrosurgery in the Treatment of Cancer."

85. MME. N. DOBROVOLSKAIA ZAVADSKAIA
"What is an Elective Action of the Penetrating Rays on the Living Cell?"

JOSEPH BLOODGOOD, M.D., Baltimore
Bone Clinic.

LEOPOLD JACHES, M.D., New York City
Clinic.

ERNST A. POHLE, M.D., PH.D., Madison, Wisconsin

W. S. PECK, M.D., Ann Arbor, Michigan

W. STENSTROM, PH.D., Minneapolis

JOHN S. COULTER, M.D., Chicago, Illinois
Symposium on Physical Therapy

DOUGLAS QUICK, M.D., New York City
Leader of Cancer Symposium.

ROLLIN H. STEVENS, M.D., Detroit, Michigan
Leader of Skin Symposium.

SEVENTH ANNUAL MEETING OF THE BOARD OF CHANCELLORS OF THE AMERICAN COLLEGE OF RADIOLOGY, HOTEL STATLER, DETROIT, MICH., JUNE 24, 1930

EXCERPTS FROM THE MINUTES

Election of Officers. — President-elect Stevens called for nomination of officers. Secretary Soiland nominated Fellow A. C. Christie for President-elect, and upon motion duly seconded and passed, the Secretary was instructed to cast the unanimous vote of the Chancellors for Dr. Christie.

Chancellor Pfahler placed in nomination for Vice-president Fellow Lyell C. Kinney, of San Diego. Upon motion seconded and passed, the Secretary was instructed to cast a unanimous ballot for Dr. Kinney.

Chancellor Pancoast then placed the name of Treasurer Orndoff in nomination to succeed himself, and he was duly re-elected.

The same procedure followed the nomination of Historian Trostler by Chancellor Wasson, and the Secretary cast the ballot for Historian Trostler.

The following candidates, Dr. Eugene P. Pendergrass, Dr. William E. Costolow, Dr. Frederick W. O'Brien, Dr. Louis J. Carter, and Dr. C. E. Piersall, were created Fellows of the College by the Board of Chancellors.

President Case announced the selection of six distinguished foreign radiologists for the degree of Honorary Fellowship. These are: James Heyman, of Stockholm; Ellis G. E. Berven, of Stockholm; Stanley Melville, of London; Manuel F. Madrazo, of Mexico City; J. A. Saralegui, of Buenos Aires; Pedro Barcia, of Montevideo.

BOOK REVIEWS

LEHRBUCH DER STRAHLENTHERAPIE (Text-book on Radiation Therapy). Edited by C. J. GAUSS, Würzburg. Volume IV, in two parts. Pp. 1393, with 415 illustrations in the text and 17 color plates. Published by Urban & Schwarzenberg, Berlin, Vienna, 1929. Price, 98 Marks ($23.43).

Under the direction of Hans Meyer, Editor of *Strahlentherapie,* a text-book on radiation therapy is being published in five volumes, the fourth of which, dealing with gynecological diseases, has appeared recently. It is intended to acquaint the general practitioner with modern radiation therapy in gynecology, to help the gynecologist in his work, to familiarize the radiologist with

the proper indications for radiation in this field, and to convince those gynecologists still showing a skeptical attitude toward radiation of its merits.

The first three chapters deal with the theoretical fundamentals of gynecological therapy; they discuss "Biological Principles of Gynecological Radiation Therapy" (Walther Schmitt, Würzburg); "The Physical and Technical Foundations of Roentgen Therapy" (Hermann Wintz and Walther Rump, Erlangen); "The Physical and Technical Foundations of Gynecological Radium Therapy" (Th. C. Neeff, Würzburg). Then follow the clinical contributions under the following headings: "The Roentgen Treatment of Uterine Fibroid and Hemorrhagic Metropathy" (C. J. Gauss, Würzburg); "The Treatment of Non-malignant Gynecological Diseases by Radio-active Substances" (H. Kupferberg, Mainz); "The Radiation Treatment of Tuberculosis of the Female Genital Organs" (Heinrich Eymer, Innsbruck); "Rare Indications for Gynecologic Roentgen Treatment" (Emil Vogt, Tübingen); "Roentgen Therapy of Malignant Tumors of the Genital Organs" (Ludwig Seitz, Frankfurt-am-Main); "The Radium Treatment of Malignant Neoplasms in Gynecology" (Ernst Ritter v. Seuffert, München); "The Post-operative Roentgen Therapy and General Treatment of Gynecological Carcinoma" (K. Warnekros, Dresden); "The Roentgen Treatment of Mammary Carcinoma" (Hermann Wintz, Erlangen); "The Roentgen Treatment of Carcinoma of the Breast" (Hans Holfelder, Frankfurt-am-Main); "Dangers and Injuries in Gynecological Deep Therapy" (Wilhelm Flaskamp, Erlangen); "Light Therapy in Gynecology" (Heinrich Guthmann, Frankfurt-am-Main); "The Rôle of Diathermy in Gynecology" (W. Lindemann, Halle a.S).

A scrutiny of the names of the contributors leads one to expect a source of valuable information in this book and the reader is certainly not disappointed. The addition of the last two chapters on "The Use of Light and Diathermy in Gynecology" adds to the completeness of the presentation of the subject. Most articles are well illustrated and accompanied by extensive bibliographies. C. J. Gauss (Würzburg), one of the pioneers in gynecological radiation therapy, who edited this fourth volume, can well be proud of the results of his efforts.

E. A. P.

PROSTHETIC DENTISTRY: An Encyclopedia of Full and Partial Denture Prosthesis. By IRA GOODSELL NICHOLS, D.D.S., Lieut. Comm. D.C.–V.(S.), U.S.N.R., *Special Lecturer and Instructor* in Dental Prosthesis, Dental Dept., U. S. Naval Medical School, Washington, D. C., with the collaboration of forty-five authorities. Pages 687, illustrations, 830, color plates, 3. Price $12.50. Published by C. V. Mosby Company, St. Louis, U. S. A., 1930.

Dr. Nichols has given the profession something different in his recent volume, "Prosthetic Dentistry." It is truly an encyclopedia covering the subject most thoroughly. Some of the best men in the dental profession have collaborated with him. In addition to dealing with prosthetic dentistry, he has dealt with the surgical phase; the injured patient; as well as with the surgical preparation of dentures.

The chapter on "A Consideration of Bacterial Growths on Artificial Dentures as the Cause of Chronic Denture Palatitis," by W. J. Pryor, is particularly interesting since nearly every dentist has had more or less trouble with inflammatory conditions caused by artificial teeth and has been at a loss to account for these unsatisfactory results.

Dr. Howard H. Jackson's article, "Intra-oral Radiography in Denture Prosthesis," is of extreme importance and will surely be

well received by its readers. He lays stress on knife-edge ridges, and residual areas of infection, each of which are many times overlooked. This chapter will add materially to the knowledge of any dentist who is interested in denture work.

Arthur E. Smith has covered block anesthesia in his usual competent manner. The photographic work is excellent and the illustrations in general make the chapter easy to read.

Dr. Menifee R. Howard's report of "An Unusual Case of Alveolotomy" shows what can be accomplished from the surgical aspect of a most difficult case.

Dr. George M. Dorrance has treated his subject, "Torus Palatinus," in a most satisfactory way. It deals with the anatomic variations as well as the technic of a most successful operation.

V. H. Kazanjian has taken up the subject of "Prosthetic Restoration of Deformities of Face and Jaw" in a manner which will be found unusually interesting and instructive to any dentist who deals with this phase of oral surgery.

"The Treatment of Edentulous Jaw Fractures," by J. Orton Goodsell, Jr., adds materially to the book and as a reference work will be of much value to any dentist's library.

"Cast Gold Full Dentures and Immediate Gold Dentures," by Sidney S. Jaffe; "Stress-breaking Partial Denture and Removable Bridge Construction," by L. M. Farnum; "The Tube Attachment," by Henry P. Boos; "Akers' Technic," by Polk E. Akers, himself; "Gum Blocks for Partial Dentures," by Walter M. Bartlett, and "Continuous Gum Partial Dentures and Removable Bridges," by James L. Howard, are all valuable chapters, each author dealing with his subject in a most intelligent manner. There are other contributors whose articles are of equal interest.

Dr. George M. Hollenback's chapter on "The Preparation of Vital Teeth as Bridge Abutments and the Construction of Attachments" is well illustrated and easy to be understood.

All in all, the book is a splendid one, and undoubtedly will be well received by the profession.

ABSTRACTS OF CURRENT LITERATURE

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EXPERIMENTAL STUDIES

The Effect on Serum Calcium of Roentgen Irradiation of the Splenic Area. Enrico Benassi. Rivista di Radiologia e Fisica Medica, May, 1930, II, 311.

The author irradiated the splenic region of two groups of five rabbits each with strong and light doses of X-rays to determine the effect on the level of calcium in the blood serum. Light doses produced no demonstrable effect. Strong doses, on the contrary, produced a marked and lasting effect by depletion of the calcium reserve of the body. In this the author finds an explanation of the biologic effect of X-rays as an alteration in the function of the spleen, and, from this, a change in the endocrine balance of the body.

E. T. LEDDY, M.D.

Studies on the Natural Immunity of Chickens to Anthrax Following Roentgenization. Giovanni Balestra. Rivista di Radiologia e Fisica Medica, January, 1930, II, 60.

One group of chickens was given general irradiation, with sublethal doses, and inoculations were made at varying intervals afterwards. In the second group, localized areas were treated with erythema doses and these areas were inoculated. In no case could the anthrax bacillus be found in the blood stream of these chickens. The author concludes that X-rays do not alter the immunity of chickens to anthrax.

E. T. LEDDY, M.D.

Protection Afforded by Short Infra-red and Red Rays to a Lethal Dose of Staphylococcus. Leonard Hill and Albert Eidinow. Brit. Med. Jour., March, 1930, No. 3,608, p. 388.

The rays from a "Beam" radiant fuel gas fire were used. Rabbits used in the experiment were about two kilograms in weight, shaved on both sides, and exposed in a wire cage to the cross-fire of two gas fires. A fan was kept running to keep the body temperature from rising more than two or three degrees Fahrenheit.

The dose of staphylococcus culture injected in each rabbit was 0.6 c.c.; this dose proved lethal to all the non-irradiated control animals in the average time of 1.2 days. Protection was afforded by "Beam" gas-fire radiation, but dark heat radiation of unshaved rabbits did not appear to have any protective power. It was concluded that the short infra-red rays and red rays had the power—by acting on the skin—of increasing resistance to a general staphylococcal infection.

WALLACE D. MACKENZIE, M.D.

The X-ray Absorption Spectrum of the Chorio-allantoic Membrane of Chick Embryo and the Emission Spectrum of the Ash of the Egg of the Domestic Fowl: A Preliminary Communication. William H. Love. Med. Jour. Australia, Sept. 21, 1929, II, No. 12, p. 395.

This paper deals with a field of X-ray research which has been developed following upon the observation of Dr. Moppett that certain narrowly defined wave length bands, notably, 0.8 and 0.5 Ångström unit, exert selective damage upon the chorio-allantoic membrane of the chick. The fact that these two wave lengths correspond to the L absorption edges of lead and uranium, respectively, gave rise to the suggestion that the mechanism of this selective effect arose from the presence of these metals in the tissue. Chemical evidence of the presence of these elements having already been given, the author now investigates the X-ray absorption spectrum of the chorio-allantoic membrane with a Müller spectrometer. Two absorption lines were found, one corresponding to the L_2 discontinuity of uranium and another with the L_2 discontinuity of lead.

The fact that a line absorption was found and not the more usual absorption band and edge is highly interesting. This phenomenon has been noticed before by Lindh in connection with the K absorption of sulphur in gypsum, which showed line and not band

absorption. The author makes the suggestion that when the absorbing element is in a highly dispersed form the absorption phenomena are modified. That is to say, the ratio of the number of absorbing atoms to the number of quanta of X-ray energy which impinge upon them influences the absorption process. The ordinary laws for the absorption of X-rays have been developed experimentally upon thick slices of materials where there are many more absorbing atoms than there are quanta to be absorbed. Where the situation is reversed, and there are many more quanta presented to the material than there are atoms to absorb them, the absorption process may undergo modification. An atom occupied in absorbing one quantum may not be able simultaneously to absorb another.

These suggestions are highly significant in connection with the practice of radiotherapy, where we may suppose the human body, like the chick membrane, to contain heavy atoms in such low concentration that different absorption phenomena may manifest themselves.

The work needs to be confirmed.

J. G. STEPHENS, M.D.

Studies on Roentgen Sensitization. III.—The Sensitizing Effect of Thorium Nitrate. S. A. Nikitin. Strahlentherapie, 1930, XXXVI, 745.

White mice, rats, and guinea pigs received subcutaneous and intracutaneous injections of a 10 per cent thorium nitrate solution in water. Some animals were also exposed to roentgen rays either before or after injection. Technic: 230 K.V., cardboard filter, 0.5 mm. Al, 1.0 mm. Al or 0.5 mm. Cu + 1.0 mm. Al, 370 to 640 r. It appeared that the effect of a combined application of roentgen rays and thorium nitrate was not dependent upon a secondary electronic emission from thorium. Roentgen irradiation of injected animals did not show any qualitative changes as compared with the effect of the injection alone. The toxic action of the thorium nitrate was increased by irradiation because its resorption was hindered.

ERNST A. POHLE, M.D., PH.D.

GALL BLADDER (NORMAL AND PATHOLOGICAL)

Symptomatical Importance of Deformed Gall-bladder Shadows. Fritz Eisler. Wien. Klin. Wchnschr., July 24, 1930, XLIII, 945.

One may distinguish between true and false deformities of the gall-bladder shadow, as demonstrated by the dye method. True deformities are caused by organic changes in the gall-bladder wall or by processes in the surrounding organs. Kinks in the outline of the gall bladder are seen fairly often. It cannot be stated definitely whether or not this anomaly may lead to symptoms. Congenital malformation of the gall bladder has been seen occasionally, also gall-bladder deformities caused by variations in the hepatoduodenal ligament. The demonstration of adhesions is only rarely possible; an hour-glass gall bladder was found to be caused by adhesions in some cases. The pseudodeformities are caused by the projection or by displacement and pressure from neighboring organs (stomach, intestines, kidney). The pseudodeformities of the gall bladder appear to be more frequent than the true organic deformities.

H. W. HEFKE, M.D.

Simultaneous Biliary Drainage and Cholecystography for Confirmation of the Meltzer-Lyon Test. Pedro L. Fariñas and Fernando Milanés. Arch. de la Sociedad de Estudios Clinicos de la Habana, May, 1929, XXIX, 245.

The authors discuss at length the confirmation of the Meltzer-Lyon test by means of cholecystography, using biliary drainage after gall-bladder iodization, with the idea of establishing the advantages, if any, of doing cholecystography and biliary drainage simultaneously. They base their conclusions on the results obtained in thirty-one cases of normal and pathological gall bladders, verifying the

reduction in size and disappearance of the gall-bladder shadow when stimulated. They obtained amounts of bile "B" (Lyon) in proportion to the reduction in size of the gall-bladder shadow. The opposite was also demonstrated, *i.e.*, that there was no reduction in size of the gall bladder where no bile "B" was obtained.

The authors do not see any advantage in making both the Meltzer-Lyon and Graham tests.

M. VIAMONTE, M.D.

Cholecystography. C. J. Johannesson. Northwest Med., June, 1930, XXIX, 256.

Cholecystitis is one of the most common causes of abdominal symptoms; therefore the development of gastro-intestinal studies in combination with cholecystography is important. One should use the technic with which he is most familiar and work in close co-operation with physician and surgeon. This author uses the oral method because of its convenience. Twelve hours after the dye is taken, films are made in inspiration and expiration; then the barium meal is given for study of stomach and duodenum. Four hours later the sixteen-hour films of the gall bladder are made; then a fatty meal is given and films made two hours later, to study the effect of fat on the gall-bladder function. The classification suggested by Case is used and recommended as a means of correlating the results of various workers.

W. W. WATKINS, M.D.

Gall-bladder Disease: A Consideration from a Diagnostic Viewpoint. Virgil E. Simpson. Jour. Indiana St. Med. Assn., July, 1930, XXIII, 305.

Cholecystography is now a well recognized and universally used method of gall-bladder study. In correlating the symptoms with the X-ray evidence of disturbed function, one must ask how much disturbance there can be that yet produces no symptoms, or whether there can be enough disturbance of function to produce symptoms without a corresponding degree of pathology. The author agrees with Graham that this latter condition can exist. Cholecystography is more than a mere functional test of the gall bladder; it is the nearest approach to actual knowledge of the anatomic condition that is afforded by any means aside from visual inspection after operation. There should be a uniform technic, whether oral or intravenous methods are used. In the intravenous method, the author's technic is to give the dye at 8 A. M., withholding breakfast, with films at four hours and again at six hours; then a fatty meal with films one hour later and as many subsequent times as the case demands. In oral administration, following a supper free from fats, four grams of dye are given at 8 P. M., with films at 9 A. M. the following morning, withholding breakfast; then a fatty meal and films one hour later and thereafter as warranted. Graham's definite claim that absence of shadow after intravenous dye is positive proof of gall-bladder disease is questioned, Hines apparently having proven that in cases of achylia the gall bladder may not outline. The simultaneous study of liver function and gall bladder with dye, as suggested by Cole and his associates, has not proven entirely satisfactory as yet, though the principle is good.

W. W. WATKINS, M.D.

Is Cholecystography an Examining Method for the General Practitioner? Ferdinand Lebermann. Deutsche med. Wchnschr., June 27, 1930, LVI, 1087.

The author discusses in detail the value of cholecystography for the physician in general practice, and comes to the following conclusions: During the last five years, cholecystography has been developed into a very valuable diagnostic method. It gives information as to the patency of the ducts, the condition of the gall-bladder wall and its surroundings, and usually permits the exclusion of gall-bladder disease in doubtful cases. The technic is simple and not dangerous when using the oral method. The intravenous application is unsuitable for the general practitioner, and rec-

tal or duodenal applications are not essential. The oral method can be used by every physician in the residence of the patient, and does not bother the patient to any extent. The expense for the examination must be called reasonable. There is no doubt, then, that cholecystography belongs to the diagnostic methods of the general practitioner.

ERNST A. POHLE, M.D., PH.D.

Diagnosis of Galltract Disease. William A. Swalm. Northwest Med., June, 1930, XXIX, 247.

The gall bladder is only a unit in a complex system, which must be borne in mind in interpreting symptoms and laboratory findings. In cholecystography two factors must be borne in mind: if the gall bladder fills, concentrates, and empties, it is believed to be normal, regardless of the method by which dye is given. Cholecystographic study cannot differentiate between cystic duct obstruction due to catarrh and that produced by adhesions, stone block, or stricture. The shadow is dependent upon the weight of the patient, thickness of the abdominal wall, and a consideration of the density of other structures in contrast with the gall bladder.

W. W. WATKINS, M.D.

The Diseased Gall Bladder. B. B. Davis. Nebraska St. Med. Jour., June, 1930, XV, 220.

The diagnosis of gall-bladder disease is often exceedingly simple and yet sometimes it challenges the resources of the most experienced. The three important steps necessary to arrive at a diagnosis and their relative importance are: (1) a careful history (70 per cent); (2) a painstaking physical examination (20 per cent); (3) various laboratory tests (10 per cent). When all possible information has been obtained from the history and physical examination, and not until then, is it time for laboratory tests. The laboratory procedure which seems to have the greatest value at present is the Graham-Cole test, the chief value of which is not to point out pathology, but to show gall-bladder function.

This author does not think it important whether the dye is given intravenously or orally. When it has been correctly applied and the results intelligently interpreted, how fully can it be relied upon? He quotes Graham to the effect that the positive findings were shown at operation to be correct in 97.8 per cent of 446 cases. In negative results, of 115 cases, only 74 per cent were found at operation to be free from pathology. Therefore, when the clinical picture of gall-bladder disease is confirmed by the dye test one can confidently recommend operation; on the other hand, if the clinical diagnosis is positive, one can proceed with operation even in the face of a negative Graham test.

W. W. WATKINS, M.D.

Physiology and Surgery of the Biliary Tract. R. R. Kahle. Ohio St. Med. Jour., July, 1930, XXVI, 602.

Cholecystography has been an invaluable aid in the diagnosis of gall-bladder disease. A careful history and physical examination, supplemented by cholecystography, usually suffice to make a correct diagnosis. The gall-bladder wall has been shown by the work of Judd and Mann to be particularly vulnerable to both chemical and bacteriological invasion. The present-day treatment of cholecystitis and cholelithiasis, in the presence of well-defined symptoms, is essentially surgical. The ideal treatment to be sought in the future must be prophylactic, to prevent infection and biochemical imbalance of the biliary tract.

W. W. WATKINS, M.D.

GASTRO-INTESTINAL TRACT (DIAGNOSIS)

Intramural Inflammation of the Colon Simulating Cancer. Whitfield Crane. Jour. Am. Med. Assn., July 26, 1930, XCV, 261.

In inflammatory tumors of the intestinal tract the majority are found in the colon. While these lesions may apparently be found in any segment of the large bowel, the ileocecal region seems to be the one commonly af-

fected. The pathologic changes are fairly uniform. A definite thickening of the bowel wall obtains, which forms a distinct tumor involving most of the coats. These lesions must not be confused etiologically with those commonly seen arising on a basis of diverticulitis.

Local infection is favored over metastatic in etiology. Various observers have classified them differently. From a practical standpoint there is an intramural chronic inflammatory condition of the bowel wall, the gross picture simulating in every particular either cancer or infectious granuloma.

One case is reported in which complete function was restored after a two-stage operation.

CHARLES G. SUTHERLAND, M.D.

Acute Intestinal Obstruction—Its Diagnosis by the Flat X-ray Film. Marcus H. Rabwin and Ray A. Carter. California and Western Med., July, 1930, XXXIII, 483.

The authors have been impressed by the fact that acute intestinal obstruction is one of the most common emergencies found at the Los Angeles County General Hospital, and that the prognosis is better in those patients having an early diagnosis than in the late cases. They use a flat film in this diagnostic work. The patient is given a "1-2-3" or milk and molasses enema in order to clear the bowel of gas below the obstruction, if one exists. The exposure is made in the same manner as a kidney film, and is seen by the roentgenologist and the surgeon as soon as it is developed.

The radiographic evidence of obstruction is based upon gas-filled, distended intestines, the distinction between colonic and small bowel obstruction depending upon the identification of distended gut as colon or small bowel. Normally there may be very little or a great deal of gas in the colon and a small amount scattered in the small intestines. The thing they look for to indicate obstruction, however, is distention. Gas under pressure is abnormal. While it does not always indicate a mechanical obstruction, its presence demands an explanation, and it is in the analysis of these abnormal shadows, considered in connection with the clinical picture, that the diagnostic value of the method rests. In the early stages distention is moderate.

A differential diagnosis from the X-ray plate at times presents many difficulties. Some of these the authors have been able to work out after critically reviewing their errors: others they are still unable to solve. In the case of obstruction in the large bowel the story is usually obvious, the colon assuming giant proportions, with the gas column ending sharply.

In a typical case of ileus one sees numerous coils of only slightly or moderately distended small bowel, associated with gas in the large intestine. The abdomen in ileus may be tightly filled with innumerable gas-filled coils, none of which exhibits the signs of great internal pressure. In some cases, however, the dilatation of the small intestine is extreme and the colonic gas small in amount. The case is then not radiographically distinguishable from mechanical obstruction.

F. B. SHELDON, M.D.

The Association of Chronic Ulcerative Colitis and Multiple Polyps. J. Arnold Bargen and Mandred W. Comfort. Ann. Int. Med., August, 1930, IV, 122.

In 10 per cent of cases of chronic ulcerative colitis multiple polypi develop eventually. This estimate is based on a study of 693 cases of ulcerative colitis.

Inflammatory disease or chronic irritation of the mucosa seems to play a significant part in the etiology. Microscopic examination of the polypi shows all stages of chronic inflammation, with numerous nests or groups of glands enclosed in a dense inflammatory network, and these findings raise the question as to whether or not these polypi are prone to undergo malignant degeneration.

The best method of examination is the use of the barium enema, supplemented by the use of the proctoscope. Polyposis in the presence of chronic ulcerative colitis may offer a grave prognosis.

Polyposis of the large bowel occurs after severe colitis or in longstanding, slowly pro-

gressing colitis, in which there is a tendency to recurrent severe exacerbations of the disease. The polypi contain large amounts of inflammatory tissue. The authors have had an opportunity to see their patients in severe exacerbations of bacterial chronic ulcerative colitis, with formation of polypi later, and finally with malignant disease.

C. H. DEWITT, M.D.

Multiple Diverticula of Small Intestine. John R. Boling. Jour. Am. Med. Assn., July 26, 1930, XCV, 267.

In 1925, the literature showed thirty-three cases of diverticula of the jejunum. Of this number, nineteen were multiple; only ten were found at operation.

One case is reported in which the roentgenograms were unsatisfactory. The terminal jejunum and ileum were studded with diverticula, springing from the mesenteric border of the intestine, and ranging in size from that of a pea to a walnut. An enterostomy was done in the jejunum and recovery was uneventful. A series of roentgenograms two months later failed to show the diverticula plainly enough for a definite diagnosis.

CHARLES G. SUTHERLAND, M.D.

Physiologic and Chemical Studies Following Successful Total Gastrectomy for Carcinoma. Waltman Walters. Jour. Am. Med. Assn., July 12, 1930, XCV, 102.

Subtotal gastrectomy for carcinoma of the stomach has established itself as a procedure of relative safety, with excellent results for the cure of malignant conditions. When even the smallest amount of gastric wall has been allowed to persist, this portion increases in size until it becomes almost as large as a normal stomach.

Experimental studies have shown that alkalosis and depletion of blood chlorides occurred and were proportionate to the loss of these constituents in the acid gastric secretion. When incomplete intestinal obstruction was maintained after total gastrectomy in animals, and the excretion of acid and chloride by way of the stomach therefore was absent, there was little depletion of chlorides in the blood or little change in the carbon dioxide combining power of the blood.

In the author's case, the concentration of chlorides in the blood was not lowered and the carbon dioxide combining power of the blood remained practically normal over a period of more than four months. There has been some disturbance in the acid-base equilibrium, as evidenced by the absence of an alkaline tide. Studies made of chemical changes in the blood, and of the cell count over a period of four months do not reveal any appreciable change in the number of erythrocytes, in the content of the hemoglobin, in the carbon dioxide combining power, or in the concentration of blood chlorides or urea.

CHARLES G. SUTHERLAND, M.D.

Congenital Diverticula in the Greater Curvature of the Fundus of the Stomach. Warde B. Allan. Canadian Med. Assn. Jour., July, 1930, XXIII, 43.

This is a case report of a white female, aged 43 years, who was admitted to the Montreal General Hospital. A diagnosis of coronary thrombosis was made, which was confirmed at autopsy.

The special point of interest is, however, the accidental finding at autopsy of a diverticulum in the greater curvature of the fundic portion of the stomach. The diverticulum was a globular pouching 4 cm. in diameter, and situated 6 cm. from the cardio-esophageal junction. It appeared to be made up entirely of mucous membrane and serosa. There was no evidence of old ulcer; it was evidently congenital. There had been no history of symptoms produced by the diverticulum.

L. J. CARTER, M.D.

Imperforate Anus: A Method of Determining the Surgical Approach. Owen H. Wangensteen and Carl O. Rice. Ann. Surg., July, 1930, XCII, 77.

Atresia of the anal canal or lower portion of the rectum occurs approximately once in every 5,000 births. Clinically, casual inspec-

tion of the perineum in the newborn will usually demonstrate the presence of imperforate anus. The child normally takes his feedings in the usual manner for twenty-four hours before regurgitation commences. There is gradual distention of the abdomen. In some instances, internal fistulous communication exists with the bladder, urethra, or vagina. Early establishment of communication with the exterior is necessary in complete atresia of the anal canal or rectum. To date, no satisfactory method has been devised to determine whether or not the atresic bowel should be approached from below or above.

A roentgen-ray method is presented by the authors which proved of value in two cases. If the child is held upside-down in the inverted position by the lower extremities, the gas in the rectum will rise to the top and indicate the distance intervening between the rectal wall and the skin of the anal dimple, when a flat X-ray film is made. Roentgenograms included appear to be convincing.

F. B. MANDEVILLE, M.D.

A Proper Gastro-intestinal Examination. N. B. Newcomer, Elizabeth Newcomer, and C. A. Conyers. Colorado Med., July, 1930, XXVII, 257.

A proper gastro-intestinal examination must determine whether each and every portion of the gastro-intestinal tract is or is not diseased; also whether pathology elsewhere in the body is giving rise to gastro-intestinal symptoms. It is surprising how often it is necessary to make a careful examination of the kidneys by means of the X-ray in order to eliminate them as possible causes of such symptoms. In making such a proper examination, it is necessary to take a careful history, to make a careful physical examination, and to correlate these with the X-ray findings. It may be necessary to examine the stomach contents, the urine, and the blood. The X-ray examination should include the teeth, esophagus, stomach, duodenum, appendix, colon, and an extremely careful examination of the gall bladder. We must exclude all conditions above and below the diaphragm which may simulate gastro-intestinal disease, such as pneumonia, tuberculosis, carcinoma of the mediastinum or lungs, pleurisy, pneumothorax, abscesses in the lower lung, aneurysm, myocarditis, angina, arthritis or tuberculosis of the vertebræ, kidney lesions, pregnancy, etc. The diagnosis must explain all the symptoms and one must be on the alert for other conditions not causing symptoms.

W. W. WATKINS, M.D.

The *Ascaris Lumbricoids* of the Gastro-intestinal Tract Simulating Appendicitis. V. O. Abgarov. Vestnik Rentgenologii i Radiologii, 1930, VIII, No. 1, p. 93.

The author reports three cases in which he succeeded in demonstrating the presence of *Ascaris lumbricoids* in the gastro-intestinal tract by means of the roentgen rays. In two cases the worms were found in the small intestine; in the third case they were found both in the intestines and stomach. Roentgenologically they are recognized as narrow transparent bands within the lumen of the intestines amidst the opaque medium. Since they are most frequently found in the small bowels, it is important to make fluoroscopic observations shortly after the administration of a barium meal. The use of pressure during the fluoroscopic observations or during the taking of the roentgenograms will reveal the worms to greater advantage. The clinical manifestations of all the cases were strongly suggestive of appendicitis.

SAMUEL BROWN, M.D.

Changes in the Position of the Intestinal Tract by Processes Outside of It. H. Pansdorf and E. Kraas. Röntgenpraxis, July 1, 1930, II, 594.

A roentgen examination can give us a diagnosis of location and origin of extra-gastric and extra-intestinal processes by their indirect action on the gastro-intestinal tract. A very thorough roentgenologic examination of the entire intestinal tract may be necessary, especially considering the "mucosa-diagnosis." Only if the mucous membrane can be shown to be entirely intact, should one exclude a disease of the stomach and intestines. Dif-

ferent positions before the fluoroscope are essential and manual palpation is of great help. A large liver may cause a filling defect similar to that caused by a gastric carcinoma. A large spleen may cause a definite change in position of the stomach and intestines. Tumors of the pancreas may lead to a picture simulating a filling defect in the stomach. Enlarged kidneys lead sometimes to a compression and displacement of the colon. Retroperitoneal tumors may show the same behavior and can be differentiated only by a pyelogram. An enlarged uterus, large ovarian cysts, and other pelvic tumors usually push the small intestines upwards.

H. W. HEFKE, M.D.

Lymphoblastoma Involving the Stomach—Roentgenologically Considered. Howard E. Ruggles and Robert S. Stone. California and Western Med., July, 1930, XXXIII, 486.

Lymphoblastoma of the stomach is such a rare condition that no one roentgenologist is likely to see more than a very limited number of cases; therefore it is necessary to pool experiences. A review of the reported cases and of those here presented shows that a majority have been diagnosed as carcinoma. Surgery has very little to offer to either carcinoma or lymphoblastoma: X-ray therapy has a great deal to offer to the latter. If it were possible to differentiate these conditions without an exploratory operation, which has a high primary mortality in these often emaciated patients, it would be of great help. The object of this study is to determine if any such differentiation is possible.

It should be possible with any given lesion to study its pathology and from it predict the X-ray findings. On this basis, lymphosarcomata of the stomach should show the following changes roentgenologically: The earliest lesions, being simply mucosal invasions, should not interfere with form or function, and, therefore, not be demonstrable. The more extensive mucosal and submucosal invasions produce a wall of more rigid appearance, or, if large enough, a filling defect. This defect will be annular diffuse, rugose, or polypose, according to the type of the process. In these respects they may closely resemble carcinomata and polyposis. Junghaven, however, has pointed out the important fact that, owing to the late invasion of the muscular layers, there is a time in the development of lymphosarcomata when there is sufficient infiltration to produce filling defects or somewhat rigid walls, and yet peristalsis can be seen. This seems to be the only diagnostic sign possible from a pathological point of view. It does not, however, separate the polypoid type from benign polyposis, which differentiation must be made clinically. The advanced stages of lymphosarcoma when the muscle is involved closely simulate carcinoma, but the defects may be of an unusual type.

Eleven cases of lymphoblastoma of the stomach are presented from a roentgenological aspect, with the pathological findings necessary to explain the changes demonstrated by the X-ray. It is shown that there is no type of lesion or region of involvement characteristic of lymphoblastoma, and, therefore, no characteristic roentgen findings. When, however, gastric peristalsis persists with a lesion of the stomach it is most likely to be lymphoblastoma. Gastric polyposis in a patient clinically suspected of malignancy should be regarded as a lymphoblastic lesion and its response to X-ray therapy tried.

F. B. SHELDON, M.D.

Advances in the Study of Gastro-intestinal Disease. Joseph W. Larimore. Jour. Tennessee St. Med. Assn., July, 1930, XXIII, 233.

To the roentgen ray and its adaptation to the needs of gastro-intestinal examination may be credited much of our increased clinical knowledge of the alimentary tract. X-ray examination of the gastro-intestinal tract is now a matter of daily routine and is in danger of becoming commonplace. Conceptions of the anatomy of the alimentary tract have changed with the ability to study it in the living organism. The size, shape, and position of the stomach have been found to vary with the physical status of the individual, and also the motility varies directly with the bodily

habitus. The addition of the Graham dye test has been of inestimable value. The roentgenologic serial examination should include the entire tract by fluoroscopic and film examination six and twenty-four hours after the initial ingestion of the opaque meal, and later with an opaque enema. All the findings from this examination should be correlated with other clinical and laboratory data.

W. W. WATKINS, M.D.

GASTRO-INTESTINAL TRACT (THERAPY)

The Treatment of Gastric and Duodenal Ulcer. Frank H. Lahey. Jour. Am. Med. Assn., August 2, 1930, XCV, 313.

The incidence in the author's series was duodenal ulcer 85 per cent; gastric ulcer 10 per cent, and gastrojejunal ulcer 5 per cent. Hemorrhage had occurred in 18 per cent of the duodenal ulcers, in 18 per cent of the gastric, and in 32 per cent of the gastrojejunal ulcers. Obstruction occurred in 7.8 per cent of the patients with duodenal ulcers, 18 per cent of those with gastric ulcers, and 20 per cent of those with combined duodenal and gastric ulcers. Eleven per cent of the patients under treatment for ulcer have been operated on and the remainder treated medically.

There are certain fairly constant features associated with peptic ulcers, such as pylorospasm, hyperperistalsis, and hyperacidity. Pylorospasm is probably the causative factor in hyperperistalsis, hyperaccumulation of gastric secretion, and hyperacidity.

Any method of treatment includes in it prominently measures directed against pylorospasm. In the surgical treatment of peptic ulcer to-day, no measures are considered practical which do not attempt to alter or offset the effects of pylorospasm.

That the ulcer is the result of and not the cause of whatever physiologic change or changes accompany it, is suggested by the fact that complete relief from symptoms as well as healing of the ulcer frequently occurs without removal of the ulcer itself.

The essayist stresses the need of attention to all the painstaking details of any form of medical management, the necessity of patients accurately persisting with it over a long period of time, and the essential requirement that patients change their habits of life as to eating, smoking, drinking, and resting. Indications for surgery are: failure to obtain relief under medical management, perforation, hemorrhage in spite of good non-operative management, non-relievable pyloric obstruction, and malignant degeneration or suspicion of it in a gastric ulcer.

A large proportion of patients with pyloric obstruction occurring with active ulcer symptoms can be relieved of their obstruction by non-operative measures.

Of all gastric lesions coming to the clinic, about 50 per cent are frankly malignant and not to be confused with ulcer.

Patients with gastric ulcer are placed in hospitals on accurate medical management. As long as the gastric defect continues to diminish in size and symptoms are completely relieved, surgery is not indicated. If the lesion can be made to disappear entirely as shown by roentgen examination, it is obvious that surgery is not indicated. Otherwise the lesion is regarded as an intractable ulcer or an early carcinoma, and surgery is indicated.

A discussion of surgical procedures follows. A patient who has had an ulcer, whether operated on or not, is always a possible candidate for another ulcer. There is less likelihood of recurrent ulcer and better end-results when patients are placed in just as careful medical management as if they had not been operated on, and urged to modify their habits of life just as much as they would if placed on a non-operative medical management.

CHARLES G. SUTHERLAND, M.D.

Gastric Achylia: Differential Diagnosis with the Aid of Neutral Red. M. H. Streicher. Jour. Am. Med. Assn., August 2, 1930, XCV, 326.

Gastric achylia may be classified as false achylia and true achylia. In false achylia the psychic phase of gastric secretion is suppressed, so that no free acid appears for the

first hour, but an acid curve appears after sixty minutes. In true achylia the curve of secretion does not rise, and the free acid and ferments are absent throughout.

Achlorhydria means a depression of acid secretion in the stomach in which free acid is absent but a moderate total acidity with ferment acivity is present.

According to Rehfuss, in cases of spurious achylia gastrica and in cases of gastric carcinoma with achlorhydria, histamine acts as an effective agent in producing gastric secretion containing acid and ferments. The same property of gastric stimulation has been claimed for neutral red in the differential diagnosis between true and false achylia.

The neutral red test may be used as an aid in differentiating true and false achylia gastrica, not because the dye is employed in this test but because a prolonged period is necessary to perform the test. Neutral red tests may be advantageously employed as a test of gastric function, just as any fractional method may be employed over a long period of time (more than sixty minutes). Neutral red possesses little or no property as a stimulant of gastric acidity.

CHARLES G. SUTHERLAND, M.D.

GENITO-URINARY TRACT (DIAGNOSIS)

Intravenous Pyelography. Frank Kidd. Lancet, July 19, 1930, CCXIX, No. 5,577, p. 128.

The author reports seventeen cases in which uroselectan was used, satisfactory conclusions being obtained in eleven. The results were doubtful in three cases, unsatisfactory in three, and in one patient a diagnosis of tumor was proven by operation to be an error, when the involved kidney showed multiple abscesses.

The author believes that intravenous pyelography should be used in difficult cases in which cystoscopy and ureteral catheterization are difficult or contra-indicated, *e.g.*, if a ureter is blocked by stone or stricture, if severe cystitis is present, if urethral stricture prevents cystoscopy, or in cases suspected of having ureteral fistula. Profuse hematuria can also be studied to advantage by this method. Tuberculous involvements are thought to be more safely studied by this means than by ureteral catheterization. The drug cannot be given by mouth as it causes vomiting. No iodism results from the injection, because the substance is passed through the renal tubules and out of the body without giving off any ionized iodine.

In the author's series, one patient vomited during the injection, but the condition of the others gave no cause for anxiety, and there were no unpleasant after-effects. Swick recovered from 90 to 95 per cent of the original substance from the urine within eight hours after the injection. The drug should not be used when both kidneys are known to be severely damaged, and the blood urea should be determined before the injection in doubtful cases. New values of diagnostic criteria must be developed to secure a successful evaluation of this method.

The author followed the method of Swick and von Lichtenberg, in which roentgenograms were made of the urinary tract, fifteen, forty-five, and seventy-five minutes after the injection of uroselectan, and at later intervals, if necessary.

If both kidneys are normal, the bladder is full of the opaque substance in a few moments after the injection. At this time the kidneys are also visualized and the pelves faintly outlined. After half an hour the pelves are fairly well visualized. It may take hours for these results in cases in which renal tumor is present or inflammation exists. The pelvic and ureteral shadows are at no time as distinctly visualized as by ureteral pyelography.

M. J. GEYMAN, M.D.

Solitary Cyst of the Kidney: Report of Five Cases. Herman L. Kretschmer. Jour. Am. Med. Assn., July 19, 1930, XCV, 179.

The extremely interesting and relatively rare condition of solitary cyst of the kidney has been the subject of renewed interest during the past seven or eight years. In 1920, the author reported one case and reviewed 47 cases found in the literature. An unusually interesting group of papers has appeared on

this topic, more or less recently. Some cysts are congenital, while the majority seem to belong to the class of retention cysts following obstruction.

Five cases are reported, the roentgen and cystoscopic examinations being detailed in each.

In a good roentgen film the outline of the cyst can be demonstrated in a large number of cases. The pyelogram is not typical and is not constant. Cysts in the upper pole are not easily recognized in plain films; cysts arising from the lower pole are easily recognized from the roentgenogram.

CHARLES G. SUTHERLAND, M.D.

Intravenous Urography as a New Help for the Urological Diagnosis. Karl Hutter. Wien. klin. Wchnschr., July 10, 1930, XLIII, 879.

Eighty cases have been examined by means of uroselectan without an accident. This method is absolutely indicated in children, in cases with stricture of the urethra, with suprapubic fistula, and in all cases in which the introduction of ureteral catheters is impossible for mechanical reasons. The excretion of uroselectan also indicates the functional state of the kidneys. This method is valuable not only for the urologist, but also for the non-specialist in helping him to decide whether or not urological disease is present.

H. W. HEFKE, M.D.

Intravenous Urography: Better Visualization with Compression. Samuel Lubash. Am. Jour. Surg., June, 1930, VIII, 1229.

The author emphasizes three points in this paper: (1) Compression before and during X-ray exposure; (2) increase in the dose of uroselectan; (3) withholding of urination.

Compression is obtained by the use of the Hickey rubber bag, using only a moderate amount of compression. This is instituted immediately after the last injection of uroselectan and is allowed to remain until after the first film is taken. It is reapplied ten minutes before and during the exposure of the second film, and the succeeding films thereafter. The author is unable to explain the *rationale* of this procedure, but states that very much better films are obtained. Following Swick's lead, he now suggests a 60 gram dose of uroselectan instead of the original 40 gram dose. He also urges the patient to refrain from urination, at least until after the second exposure, if possible.

HOWARD P. DOUB, M.D.

The Action of Pituitrin on the Kidney Pelvis Demonstrated by Uroselectan. F. Reimann. Med. Klinik, June, 1930, XXVI, 960.

The author investigated the influence of pituitrin, given subcutaneously or intramuscularly, on the size and contractility of the kidney pelvis, as demonstrated by uroselectan. In all pyelograms of normal persons a distinct lessening in the size of the pelvis was noted, and the calices could be demonstrated about fifteen to thirty minutes after the administration of pituitrin. Studies concerning its influence on a pathological renal pelvis are as yet not numerous enough to allow one to draw conclusions.

H. W. HEFKE, M.D.

Intravenous Urography. Gonzalo Pedroso, in collaboration with Joaquin Chappotin, Pedro Sánchez Pessino, and Juan Embil. Anales de Cirugia, June, 1930, II, 216.

The term "intravenous urography" is used by the authors to designate the intravenous administration of uroselectan, while the term "retrograde pyelography" is employed to refer to the classical ureteral injection. The authors arrive at the following conclusions: (1) Intravenous urography is primarily a functional test; (2) it has decided advantages over retrograde pyelography, but it cannot replace the latter in every instance; (3) the images obtained by this method are usually less opaque and less sharp than those obtained by retrograde pyelography; (4) retrograde pyelography maintains an unquestionable superiority over intravenous urography when renal tumors and certain ureteral lesions

are suspended: '5, Intravenous urography appears to be contra-indicated in cases of advanced renal insufficiency. '6, In a series of cases it was shown that the time of elimination of uroselectan was equal to the time of elimination of urea and phenolsulphonephthalein. '7 Up to the present time the authors have not observed any untoward symptoms after intravenous urography.

The paper is exceedingly interesting, quite complete and generously illustrated.

H. Thoms, M.D.

Intravenous Pyelography as a Test of Renal Function. Kenneth Heritage. Lancet, July 19, 1930. CCXIX. No. 5577. p. 132.

The author feels that the test of renal function by intravenous pyelography depends more upon the time that the shadows appear than the density of secreted or selected, because in many cases, largely normal, the dye is secreted so rapidly that films show only faint shadows of pelves and ureters, whereas the bladder shadow fills the pelvis. He suggests temporary compression of the ureters at the level of the sacroiliacs, and uses a pad and rubber bag similar to that used for renal compression. [illegible] compression should [illegible] frequently five minutes suffi[illegible] satisfactory outlines of the [illegible] method of course, is of no help [illegible].

The author [illegible] the use of intravenous [illegible] as a [illegible] urinary diagnosis.

M. J. Gelman, M.D.

GYNECOLOGY AND OBSTETRICS

Fetal Cephalometry *in Utero*: A Method for Estimating the Occipitofrontal Diameter, and a Statistical Study of Cephalic Measurements in One Hundred and Forty-nine Unmolded Heads. Herbert Thoms. Jour. Am. Med. Assn., July 5, 1930. XCV, 21.

A method is described which has proved satisfactory for measuring the occipitofrontal diameter *in utero*. A report is made of a statistical study of unmolded heads of new-born infants to establish the relationship of the occipitofrontal diameter to other important cephalic measurements.

The method is essentially an adaptation of the method of roentgen pelvimetry published in May, 1929. After the plane through which the occipitofrontal diameter passes has been established and the distance above the sensitive plate measured, the exposure is made with the tube at a thirty-six inch distance, centering directly over the mid-point of the diameter. A perforated lead plate is interposed in the same plane as that occupied by the occipitofrontal diameter. A flash is made in the previously exposed plate. The image of the fetal head shadow and a series of dots representing the centimeter scale in the plane of the occipitofrontal diameter will be seen on development of the roentgenogram.

Charles G. Sutherland, M.D.

Actual Problems in Gynecological Radiation Therapy. F. Seisser. Strahlentherapie, 1930. XXXVI, 671.

The author discusses briefly the technical, biological, and clinical principles of radiation therapy in gynecology. He does not recommend the so-called temporary sterilization by roentgen rays or radium, and believes that there is no direct effect of radiation on uterine fibroids.

The article closes with an emphasis on the importance of individualized treatment in all cases subjected to radiation therapy.

Ernst A. Pierce, M.D., Ph.D.

The Woman's Bill of Rights. E. G. C. Williams. Illinois Med. Journ., June, 1930. LVII, 415.

"If a woman has a menstrual disturbance which is preventing her from leading a comfortable and useful existence, is it her privilege to go into a voluntary menopause, or should she be required to wait and let Nature take its course?"

The writer calls attention to some aspects of menstrual disturbance that receive too little attention from the medical profession, and discusses the medical, sociological, and economic phases of the production of an artificial

menopause. From his experience he concludes that an amount of X-radiation giving a saturation dose of 600 r at the depth of the ovaries will, in most cases, produce a complete menopause with little mental and nervous disturbance. Each case must be judged and accepted on its own merits.

"Let the old catamenial law be tempered with reason and administered with justice to the patient, and may we discuss freely and openly the adding to a woman's bill of rights a provision that it is the privilege of any woman to voluntarily enter the climacteric if her catamenial status is detrimental to her happiness, health, or community usefulness."

C. H. DEWITT, M.D.

Irregular Uterine Bleeding at the Time of Menopause. John H. Mullin. Delaware St. Med. Jour., June, 1930, II, 95.

Irregular uterine bleeding at the time of the menopause is not normal. Every patient having metrorrhagia or abnormal vaginal discharge should be examined thoroughly to discover the cause; if the symptoms warrant it and the patient is not a poor surgical risk, hysterectomy should be done even if malignancy is not found by curettement.

(*Note:*—This paper does not give sufficient consideration to treatment by radiation in non-malignant conditions.)

With regard to the treatment of malignant conditions, the choice between radium, X-ray, and surgery is not always easy. Each has its field in which it is clearly the best treatment, but the fields overlap.

(*Note:*—The paper does not show evidence of a very accurate knowledge of the indications for radiation treatment in uterine malignancy.)

W. W. WATKINS, M.D.

HEART AND VASCULAR SYSTEM (DIAGNOSIS)

On the Horizontal Orthoprojection of the Heart. T. Klason. Acta Radiologica, 1930, XI, No. 59, p. 57.

To obtain further information regarding the cardiac chambers in different projections, the author made anatomical studies of frozen sections of the thorax, in horizontal and sagittal planes. He also examined five cadavers in which the heart had been fixed *in situ*. One hundred and fifty normal cases were then studied by the author. He describes his method of obtaining an orthoprojection of the heart in horizontal planes, with the patient in an upright position. A series of tables gives normal measurements obtained from orthodiagrammatic study, as well as measurements in horizontal orthoprojection. He also discusses pathological variations in size and shape of the heart as determined by horizontal orthoprojection.

M. J. GEYMAN, M.D.

Calcification of Blood Vessels. Franz Melchart. Röntgenpraxis, July 15, 1930, II, 657.

Arteriosclerotic calcification of arteries in older persons is a common finding in roentgenograms of extremities and the pelvis. It is rare in younger individuals, and has been described in cases of osteosclerosis, severe osteomyelitis, fragilitas ossium, and lately after the administration of Vitamin D.

A case of a woman thirty-eight years of age is described, with very marked calcification of the vessels and smaller arteries. Vitamin D, which had been given to the patient, may be an etiologic factor in this condition.

H. W. HEFKE, M.D.

MASTOID

Acute Mastoiditis. Henry B. Hitz. Wisconsin Med. Jour., June, 1930, XXIX, 316.

Usually middle ear inflammation, with involvement of the mastoid, comes on rapidly. Within twenty-four hours, good X-ray films will usually show a diffuse blurring on the affected side, as against the clearly marked well side. The cases with the classical symptoms of mastoiditis are the exception rather than the rule. Unquestionably many an individual has lost his life from meningitis, or other complications, while the physician was awaiting the development of classical symptoms. Much may depend upon the character of the bone

structure of the mastoid. [This can be determined only by X-ray examination.—W. W. W.] It may have a thick-walled outer table, small-celled, with a thin inner wall; or a thick-walled, large-celled outer table, with a thicker inner table; or thin-walled throughout, with large, eggshell, bubble-like cells widely disseminated; or completely eburnated, with a few small cells close to the inner table.

(*Note:*—The author does not so state, but only by a thorough X-ray examination can the surgeon determine what sort of mastoid his patient has, and, therefore, what the course of infection is likely to be.—W. W. W.)

W. W. WATKINS, M.D.

Comments on the Prevention and Early Diagnosis of Mastoid Disease. Emil R. Mayerberg. Delaware St. Med. Jour., June, 1930, II, 101.

Much can be done for cases with an acute inflammation of the middle ear, if they are seen early, and mastoid disease can frequently be prevented by early recognition and proper treatment. Most of the patients lost may be truly said to have died because of the failure of "classical" signs of redness, tenderness, and swelling over the mastoid, which do not appear in the most dangerous cases. The author has become increasingly impressed with the value of X-ray findings when properly interpreted. By this method one can determine the anatomic type of the mastoid, the condition of the bone structure, the location of the lateral sinus, and whether or not the cells contain air or some exudate. The whole clinical picture must determine the advisability of operation, but the X-ray findings have a very positive value.

W. W. WATKINS, M.D.

OFFSPRING, EFFECT ON

X-rays and Germ Injury. Hans Duncker. Strahlentherapie, 1930, XXXVII, 142.

X-rays and Germ Injury: Its Relation to Gynecologic Therapy. Heinrich Martius. Strahlentherapie, 1930, XXXVII, 164.

Duncker discusses the present status of our knowledge of the genetic changes produced experimentally by roentgen rays. The investigations of Hertwig, Muller, Patterson, and others are fully related.

Martius reviews the literature on the injuries to the offspring caused by irradiating the ovaries of the mother. He cautions against unnecessary diagnostic exposures of the pelvis, particularly during pregnancy, and opposes temporary sterilization by roentgen rays or radium.

ERNST A. POHLE, M.D., PH.D.

Late Injury to the Offspring by Indirect Radium Irradiation. Fritz Dautwitz. Strahlentherapie, 1930, XXXVI, 686.

Following a review of the literature concerning the injury of the offspring due to irradiation of the mother, the author relates in great detail the history of a case which came under his observation in March, 1926. This woman developed a goiter at the age of twenty, which did not respond to iodine medication. In October, 1925, a struma in size larger than a man's fist was removed because it occasioned difficulty in breathing. In December, a swelling appeared in the skin which kept on growing, until, in March, 1926, a biopsy led to the diagnosis of angiosarcoma. Radium treatment to the neck was then started. The patient was pregnant in approximately the fifth month. The second series was administered in July, 1926, and on August 9, 1926, the patient was delivered of a normal girl, 51 cm. in length and weighing 3,800 grams. Mother and child were well until February, 1927, when a recurrence developed in the region of the right neck of the mother. Radium was given again, followed by prompt relief. In October, the patient reported that she had last menstruated in April. On January 23, 1928, a normal boy was born, weighing 3,600 grams, 53 cm. long. The first child could not walk when over one year old. In the Summer of 1928, spastic paresis developed in the legs and arms, and according to the report of the family physician, death occurred from sclerosis of the brain.

Another radium treatment to the mother was necessary because of a recurrence in December, 1928. Early in 1929, the patient had

a cyst in the right adnexa removed; she recovered well and was still free of recurrence in April, 1929. The second child developed and showed no abnormalities.

The author then discusses at length, the possibility of a radium injury to the first-born child, although the generative organs of the mother had not been irradiated directly. The total dose of radium applied over the neck and thorax was as follows: March, 1926, to April, 1929, seven series, 45,857 mg.-hrs., *i.e.*, 9,823 mg.-hrs. in March and July, 1926, during the second half of the first pregnancy; 12,228 mg.-hrs. in March, 1927; 8,216 mg.-hrs. during the second pregnancy, and 15,590 mg.-hrs. after the second delivery.

ERNST A. POHLE, M.D., PH.D.

RADIUM

Measurement of the Distribution of Gamma Rays around a Four-gram Mass of Radium: Report from the Physics Department, Westminster Hospital. H. T. Flint and L. G. Grimmett. Brit. Med. Jour., July 19, 1930, No. 3,628, p. 98.

This paper describes the method used in an attempt to measure accurately the gamma radiation field, in air, of the radium "bomb" in use at Westminster Hospital, London. The measurement is arrived at by combining an ionization chamber and gold leaf electroscope into one small instrument, thereby dispensing with connecting leads.

A table is printed giving a typical set of readings taken along a horizontal line 4 cm. below the bomb and intersecting its vertical axis. The isometric lines (curves of equal times of leak, "isodoses") per 100, 95, 90, etc., arbitrary units, were drawn by linking up the points on the various levels for which the times of leak were 5 seconds, 5.26 seconds, 5.55 seconds, etc., these numbers being inversely proportioned to 100, 95, 90, etc. A chart is given showing on a reduced scale the gamma-ray isometrics taken in a vertical diametral plane parallel to the bomb supports. It is accurate to within 5 per cent. The chart enables skin doses to be read off in arbitrary units.

Of the various units now in use in connection with the measurement of dosage in gamma-ray therapy, two which could be applied to this work are the international r-unit and the absorption unit (energy absorbed per cubic centimeter per milligram hour).

WALLACE D. MACKENZIE, M.D.

The Treatment of Keloids and Hypertrophic Scars. Albert Simons. Strahlentherapie, 1930, XXXVII, 89.

The author describes a method of treating keloids by implantation of small rods made of Thorium X (similar to our radon seeds). He feels that this method is applicable in cases in which external irradiation must fail. It is also possible to obtain high doses at a depth without over-exposing the skin. The beta rays, which are very suitable for the treatment of hypertrophic connective tissue, can be used, even in the deeper tissue parts. The protracted treatment has, according to our present knowledge, also definite advantages.

The clinical results in twenty-one cases are then recorded, accompanied by photographs of a number of patients before and after treatment. These results were excellent in thirteen cases, four patients were improved, two are still under treatment, and two did not respond.

ERNST A. POHLE, M.D., PH.D.

Distribution of Radiation from Clinical Radium Tubes. S. Russ and Dorothy F. Clephan. Lancet, Aug. 9, 1930, CCXIX, No. 5,580, p. 286.

Numerous tests were made of the effect of radium needles on photographic plates, with the needles arranged in different positions and at different distances. During these tests it was discovered that the concentration of radium inside the individual tubes is not always uniform, and photographic tests on individual tubes have shown that in some cases it can safely be said that the inequalities in strength of radium along the lumen of the tubes are such as to militate against their proper therapeutic use. A few samples of autophotographs of individual tubes are reproduced, as well as

the photographic effect of needles arranged in different groupings. Because of the marked inequalities in distribution of radium in some of the tubes used, the authors suggest that purchasers of radium may find it necessary in the future to insist upon guarantees relating to the distribution of radium in tubes, as well as certificates of purity and quantity.

(*Note:*—This is of more importance in England to-day than in the United States, as long narrow needles with very small amounts of radium are being used extensively there in the treatment of carcinoma of the breast.)

H. J. Ullmann, M.D.

The Treatment of Carcinoma of the Tonsil by Radium, and a New Method of Application. Hassan Kenan. Strahlentherapie, 1930, XXXVI, 807.

The author describes a radium applicator consisting of a mold as used by dentists in conjunction with a small metal tube through which a copper wire is inserted. The radium is attached to the end of the wire. This device permits treatment over a long period of time without interfering with the feeding by mouth. A photograph of the mold is appended.

Ernst A. Pohle, M.D., Ph.D.

Radium in Gynecology. Brit. Med. Jour., March 1, 1930, No. 3,608, p. 390.

Malcolm Donaldson speaking: In view of the imperfect knowledge of the fundamental facts governing radiosensitivity it was not surprising that most technics were empirical. From clinical observation it appeared that for certain types of growth, particularly slow-growing tumors, it was better to apply a low intensity for a long time than a high intensity for a short time.

Glands were a difficult problem, but the Columbia wax method of placing the radium over the whole inguinal area at a distance from the skin of 1 cm. has proven probably the most efficient at present available.

A rapidly growing tumor, such as chorion epithelioma, should be treated first by X-rays, and then, if the primary focus is not very extensive, radium should be used in addition.

J. E. A. Lynham speaking: The removal of septic foci, and the use of vaccines, tonics, ultra-violet radiation, and hypodermic or intramuscular medication, are recommended as of possible assistance.

Wallace D. Mackenzie, M.D.

Radium and Roentgen Rays as a Factor in Producing Mutations. H. Stubbe. Strahlentherapie, 1930, XXXVII, 124.

This is a brief discussion of the literature on the subject, followed by a preliminary report of the author's own investigations. Those interested in the subject are referred to the original for details.

Ernst A. Pohle, M.D., Ph.D.

Indications for the Use of Radium in Gynecology. Gerry R. Holden. Southern Med. Jour., July, 1930, XXIII, 662.

Many principles governing the use of radium in gynecology have been more or less universally accepted. The judgment of the gynecologist must play a great part in their application. With regard to malignancy of the cervix, the pronouncement of the committee from the American College of Surgeons justifies the faith of those who for years have felt that just as good results follow the use of radium as follow extensive operations. With regard to myomata, perhaps the majority of them should be treated surgically. But myoma calls for fine discrimination and good judgment on the part of the gynecologist, who should decide upon the type of treatment after exhaustive study of the patient. Careful gynecological examination and accurate diagnosis is the important procedure in using radium; the technic of radium administration is easy as compared with the preliminary investigations which should precede its application.

W. W. Watkins, M.D.

The Use of Radon Seeds in the Treatment of Carcinoma. H. S. Souttar. Brit. Med. Jour., Aug. 23, 1930, No. 3,633, p. 273.

Radon, or radium emanation, is a heavy gas of atomic weight 222, and is formed by the decay of radium at an absolutely constant rate, which is independent of the physical condition

of the radium, its solution, temperature, or pressure. The amount of radon in equilibrium with one gram of radium is defined as one curie, and the volume of this very potent source of energy, the physical equivalent of 1,000 milligrams of radium, is only 0.6 of a cubic millimeter. It will thus be seen that we have here the means of packing an extremely powerful source of radiation into very small compass.

All the evidence at present available goes to show that the effect produced upon a tumor is proportional to the total energy delivered, and that it is a matter of apparent indifference within certain limits whether this energy is produced slowly or rapidly, or whether its rate of production is constant or diminishing.

It is usual to collect the radon in fine glass capillaries, but these must be screened by metal sheaths to cut off beta rays, which have no selective action on the cells of carcinoma and produce a general local necrosis of the tissues. The most effective screen is platinum, and with a platinum sheath whose wall is 0.3 mm. in thickness, all but a very small fraction of the beta rays are absorbed. It has been found, however, that with such small amounts of radon as are used in seeds—usually from 1 to 2 millicuries—silver of the same thickness forms a perfectly satisfactory screen at a fraction of the cost, while it is an old observation that silver, owing to its slight antiseptic properties, is better tolerated in the tissues if left in permanently. The only exception is in the case of a growth close to a mucous or cutaneous surface, and here platinum should be used, as these surfaces are peculiarly sensitive to beta rays. The seeds may be attached to fine silk threads to be removed, but the author personally adopts this course only in such special regions as the eyelids. In most regions the seeds may be left in permanently without any ill effect.

In general, the aim in view is to produce a nearly uniform radiation of the region under treatment by as accurate a "random" distribution as it is possible to obtain.

It is a generally accepted standard of dosage that one millicurie of radon during its decay will produce a gamma radiation sufficient to destroy all carcinoma cells within a distance of 0.5 centimeters.

It is not usually realized how considerable the effect of cross-fire may be. A formula is given to calculate the amount of radon required to produce unit radiation in a tumor of given size. The seeds are introduced through a fine cannula by means of a plunger. After each introduction the cannula is withdrawn a short distance, say, 2 cm., and another seed is introduced. In this way the linear distribution of seeds can be made with great accuracy and with no further trauma than is involved in the first introduction of the cannula. Further parallel rows of seeds can be similarly introduced, or several rows may be made to radiate from one puncture. A diagram is given showing the magazine introducer used by the author.

Special considerations in the treatment of tumors of the tongue, breast, rectum, and esophagus are illustrated in turn.

WALLACE D. MACKENZIE, M.D.

What can we Expect from Radium in the Treatment of Cancer? J. Murdoch. The Lancet, May 17, 1930, CCXVIII, No. 5,568, p. 1056.

This is a long paper, and is a descripton of the method and result of the work at the University Clinic of Brussels. The author takes up in detail cancer of the skin, lips, tongue, and the cervix, and the influence of radiation on other forms of cancer, and the cancer campaign in Belgium. His dose unit is the energy unit of the C. G. S. system, and is expressed in the amount of energy absorbed per unit volume of tissue, that is, in ergs per cubic centimeter. A dose of 450,000 ergs per cubic centimeter produces a slight erythema and pigmentation, practically the same as the one obtained with 600 International r-units given in one dose with 180 kilovolts and 0.5 millimeter of copper and one millimeter of aluminum filtration. For X-rays, however, this reaction is produced only after the administration of 96,000 ergs per cubic centimeter. With radium, a dose of 550,000 ergs per cubic centimeter causes a frank erythema not followed

by desquamation, but by brown pigmentation. A dose of 600,000 causes a deep red erythema, followed by slight desquamation and deep pigmentation, and from 700,000 to 900,000 causes a strong radio-epidermitis, with formation of blisters and deep pigmentation. It is the maximum dose used in treating skin tumors.

The general basis of treatment is long exposure (up to several days), with small amounts of radium, usually heavily filtered. In cancer of the skin and lips, the results where there are no glandular metastases, are very encouraging. The author reports about a 90 per cent cure of cutaneous cancers of the face and lips, and of the deeply infiltrating tumors, about 50 per cent, but this last class includes a large percentage of hopeless and quite inoperable cases. He believes that cancer of the skin is never too large nor too advanced for treatment by radium therapy. For cancer of the tongue the method originated by Regaud is used, and he quotes Regaud's statistics of 50 per cent of all cases cured of the local lesion, and 25 per cent of all cases, both operable and inoperable, with permanent recovery.

The author is rather pessimistic regarding the successful treatment of glandular metastases. The Regaud technic is that used for cancer of the uterine cervix with minor modifications, which he describes. The intra-uterine tube is left in place for nine days. The amount of radium is from 6.66 milligrams of radium element to double this amount, with a filtration of one millimeter of platinum. The larger amount of radium is used in cases in which the canal is long and the arrangement of the two tubes is in tandem. Vaginal tubes are left in place five days. Two tubes are used, each of 13.33 milligrams with two millimeters of platinum, and are contained in cork stoppers of the Regaud type, which insure a distance of one centimeter between the walls of the tubes and the tissues.

Murdoch quotes the published statistics of Forssell and Regaud to show that it is possible to cure 40 per cent of all the operable cases, to save 16 per cent of all inoperable cases, and believes that the results will improve in the future, as the technics have been perfected since 1923, and that future statistics will reflect these improvements. The best results in cancer of the esophagus, so far a two years' survival, have been secured by external irradiation with X-rays. Cancers of the stomach and the intestine do not respond well to radium therapy. He has seen some interesting inoperable cases improved by roentgen treatment, but the time elapsed is too short to warrant a definite opinion. Cancer of the rectum is also highly radioresistant, and the results obtained are very unequal. The authors named are not yet ready to report on the value of post-operative radiation in carcinoma of the breast.

The paper is very interesting and should be read by everyone working with cancer, whether he is using radium or not, for there is still considerable ignorance among the profession as to what can be done in the inoperable types of malignancy.

H. J. Ullmann, M.D.

ROENTGEN THERAPY

Radiation Therapy of Malignant Tumors in Sweden, with Special Consideration of Radiumhemmet. Gösta Forssell. Strahlentherapie, 1930, XXXVII, 215.

This excellent article is a German translation of the Forssell-Mackenzie-Davidson Memorial Lecture. It is published in English in the *British Journal of Radiology*, May, 1930, III, No. 29, p. 198.

Ernst A. Pohle, M.D., Ph.D.

The Present Status of Radiation Therapy in Pediatrics. Ernst A. Pohle and Horace K. Tenney. Jour. Michigan St. Med. Soc., July, 1930, XXIX, 500.

In pediatrics there are a number of conditions amenable to X-ray or radium treatment; in others, the results are doubtful. The clinical groups discussed include *(a)* glands of internal secretion; *(b)* tuberculous glands; *(c)* blood diseases; *(d)* skin diseases, and *(e)* inflammatory conditions. Aldrich suggests that the disturbances relieved by treating the thymus are related to smooth muscle balance,

which may enlarge our conception of indications for treating the thymus. The following indications are given: stridor, cyanosis not due to heart disease, pylorospasm. Small doses of from 30 to 75 r, which may be repeated several times, are advised. Toxic goiter in children has a high surgical mortality and conservative treatment with radiation should be tried first. A safe dose would be 75 to 100 r over each lobe, which may be repeated in from two to five days. Tuberculous glands may be treated by X-rays of moderate penetration, from 50 to 75 r, repeated two or three times at intervals of from three to ten days. Blood diseases are treated much as in adults, there being palliation in chronic leukemia and Hodgkin's. Of skin diseases the most important group is the nevi, which yield often enough to radium to make this method worth trying. Of inflammatory conditions, the authors especially name acute cervical adenitis, which should have small doses of from 30 to 75 r. Accurate measurement of dosage and a conservative attitude in administering radiation to children is urged.

W. W. WATKINS, M.D.

Radiation Therapy as a Complete or Partial Substitute for Surgery in the Treatment of Carcinoma of the Uterus, Vagina, and Ovaries. James Heyman. Strahlentherapie, 1930, XXXVII, 254.

Heyman, the well known co-worker of Forssell, presented this paper before the Clinical Congress of the American College of Surgeons, in Chicago, October 14–18, 1929. The English reader will find it in *Surgery, Gynecology and Obstetrics,* January, 1930, L, 173.

ERNST A. POHLE, M.D., PH.D.

Late Injury to the Lens (Cataract) after Roentgen and Radium Treatment. F. S. Grosman. Vestnik Rentgenologii i Radiologii, 1930, VIII, No. 1, p. 81.

A case is described of a woman, 32 years of age, who suffered from cancer of the nose which was treated energetically with X-ray and radium. After five years, following a complete cure of her affection, cataracts of both eyes developed which required surgical interference. After a thorough analysis of the possible etiological factors, the author came to the conclusion that the formation of the cataracts was due to X-ray and radium treatment. He supports his conclusion from similar case reports in the literature (a total of 20 cases) and experimental work. He believes that this complication is more frequent than is generally recognized, and that a thorough ophthalmological examination would reveal its presence more often. Several of his own cases, after from four to six years following treatment, revealed abnormal changes in the lens on ophthalmological examination.

SAMUEL BROWN, M.D.

Principles of Roentgenotherapy: VI.—Roentgen Therapy in Internal Medicine. Ernst A. Pohle. Wisconsin Med. Jour., June, 1930, XXIX, 332.

Paper No. 6, on the Roentgen Therapy in Internal Medicine, covers the application of this method to lung tuberculosis, bronchial asthma, pneumonia, circulatory diseases, blood diseases, Hodgkin's, the spleen, polycythemia, gastro-intestinal tract, internal secretions, infectious diseases. Only carefully selected cases of lung tuberculosis should be treated, using a single dose of 50 r to 60 r of moderate penetration. In bronchial asthma a larger dose of more penetration may be given. Gastric hyperacidity is treated by followers of the Vienna school with fairly heavy doses of from 300 to 400 r at 150 K.V. In most of the conditions mentioned, caution and conservatism are advocated, although undoubtedly there is a developing field for roentgenotherapy in internal medicine.

W. W. WATKINS, M.D.

Principles of Roentgenotherapy. VII.—Roentgen Therapy in Surgery. Ernst A. Pohle. Wisconsin Med. Jour., July, 1930, XXIX, 378.

This seventh paper in this series treats of the surgical lesions in which radiotherapy is commonly recognized as of benefit. Regarding breast cancer, he quotes Holfelder's tech-

nic, but states his preference for a single subtoleration dose (500 r), with operation within five to ten days, or the saturation dose for two weeks, with operation three to five days after the last exposure.

Consideration is given in this paper to carcinoma of the lip, malignant growths in the thyroid, lungs, esophagus, stomach, colon, prostate, bladder and penis, sarcomas, inflammatory processes, and surgical tuberculosis. As examples of the outstanding problems yet remaining for future research, he mentions the value of pre-operative radiation of breast cancer, the effect of irradiation on the healing of wounds, and the most efficient treatment of bone tumors.

W. W. WATKINS, M.D.

The Diazo Reaction after Roentgen Treatment of Lymphogranulomas. K. Tschilow. Med. Klinik, Aug. 1, 1930, XXVI, 1151.

In six cases of lymphogranuloma (Hodgkin's disease) after treatment with roentgen rays, the Diazo reaction in the urine was found either markedly increased or positive after a previous negative reaction, while in cases of lymphosarcoma, glandular tuberculosis, or carcinoma the reaction remained negative. These cases are described in detail. The effect of the X-rays on the Diazo reaction can well be applied for the differential diagnosis between Hodgkin's disease and other clinically uncertain tumors. The number of the cases is too small, in the author's opinion, to state that the Diazo reaction must always be positive after radiological treatment of Hodgkin's disease.

H. W. HEFKE, M.D.

X-ray and Radium in the Treatment of Uterine Fibromyoma and Benign Menorrhagia. M. A. Thomas. Ohio St. Med. Jour., July, 1930, XXVI, 599.

During twenty-five years radiation has come with many gynecologists to be the treatment of choice in this type of case. Clark, Norris, and Miller estimate that it is to be used in 25 to 30 per cent of the cases; others who specialize in radiation give estimates up to 80 per cent. Béclère has treated 700 cases with X-ray, with failure in 1 per cent, and states that "roentgenotherapy is contra-indicated only in cases in which for some urgent reason, surgical intervention becomes absolutely necessary." Among the contra-indications recognized in this country, the most important are *(a)* necessity for positive diagnosis (if it is not possible to rule out ovarian cyst, malignancy, adnexal disease, pregnancy, etc., irradiation is not advised); *(b)* pedunculated subserous or submucous fibroids; *(c)* size of tumor has been given as governing treatment, but Kelly found that in 60 per cent of tumors larger than a five months' pregnancy, the mass reduced satisfactorily; *(d)* age, in cases in which it is desirable to preserve menstrual function. The choice between X-ray and radium is generally dependent on circumstances and personal preference, as there is no essential difference in the final results.

W. W. WATKINS, M.D.

Roentgen Treatment in Disease of the Tonsil. G. Schulte. Strahlentherapie, 1930, XXXVI, 708.

A review of the literature revealed the fact that radiation therapy of tonsillar disease is not practised so much in Germany as in other countries. The author has treated hypertrophic tonsils since 1924, with the technic stated below. For children: 140 K.V., 4.0 Al, 147 r; for adults: 210 K.V., 1.0 Cu + 1.0 Al, 170 r; 6 cm. × 8 cm. field to left and right neck, at 30 cm. F.S.D. If necessary, this dose was repeated after four and after eight weeks. Large and fibrous tonsils did not respond well and were, therefore, excluded from irradiation.

A statistical survey shows that during the last six years, 132 children (2 to 14 years old) and 125 adults were treated. Twenty-eight patients were still under treatment at the time of writing the report, and 40 patients could not be traced. This leaves 189 cases for evaluation. Ninety per cent of these were cured, 6 per cent were improved, and 4 per cent were not improved. In about two-thirds of all cases, two series of X-ray therapy were re-

quired. In the remaining one-third, one, three, or four series had to be given. Emphasis is laid upon the fact that patients suffering from repeated tonsillitis are particularly suitable for roentgen therapy.

ERNST A. POHLE, M.D., PH.D.

A Case of a Late Roentgen Ulcer Following Roentgenoscopic Study. A. G. Strelkov. Vestnik Rentgenologii i Radiologii, 1930, VIII, No. 1, p. 89.

The case described is of a male patient 29 years of age, who suffered from a gastric ulcer and a diaphragmatic hernia. During a short period, in December, 1926, and January, 1927, the patient underwent numerous roentgenoscopic studies, and finally was operated upon and made a good recovery. In April, 1928, an ulcer appeared on the back measuring 7.5×7.5 centimeters. The character of the ulcer was that of dry gangrene. After a thorough analysis of the etiological factors the author came to the conclusion that the ulcer was due to the excessive use of the roentgen rays during the examinations of the patient. It finally healed under the application of therapeutic measures.

SAMUEL BROWN, M.D.

Radiation Treatment of Uterine Fibroids and Other Non-malignant Uterine Hemorrhage. J. Donald MacRae, Jr. Southern Med. and Surg., June, 1930, XCII, 413.

These cases come first to the general practitioner, the surgeon, or the gynecologist; the radiologist sees them only when they are referred to him. It is his duty, therefore, to inform his fellow practitioners about the type of cases he can help and what results are to be expected.

Uterine fibroids and non-malignant uterine hemorrhage from other causes are amenable to radiation therapy, when properly selected, in a very large percentage of cases. The necessity for accurate diagnosis before beginning treatment is emphasized. A diagnostic curettage should be done in all women over forty years of age. The injection of lipiodol into the uterine cavity is a useful procedure in diagnosis. The chief indication for irradiation is uterine hemorrhage. There is need for balanced judgment as to the benefit offered by radiology or surgery. High voltage X-ray and radium have practically the same effect on the tissues, and the reasons for choosing one or the other are based chiefly on the convenience of delivering the one or the other at the site of pathology or the organ to be treated.

W. W. WATKINS, M.D.

The Prognosis of Adenocarcinoma of the Uterine Cervix Under Radiation Treatment. Fr. Keller. Strahlentherapie, 1930, XXXVII, 349.

During the period 1915 to 1929, 463 cases of carcinoma of the cervix were seen in the author's clinic. Nine of these cases were adenocarcinoma; in not a single case was it possible to obtain a permanent cure. The average duration of life from the beginning of the treatment was 15.4 months, which is about the same for treated or untreated cases, in spite of the fact that four of the five cases were operable. In three of the four patients who had not been observed as long as five years, a clinical cure was obtained by combining radium and roentgen treatment. The prognosis of adenocarcinoma of the cervix, therefore, is poor, although the more favorable results with the modern technic look encouraging.

ERNST A. POHLE, M.D., PH.D.

X-ray Injury Following Epilation in Hypertrichosis. Karl Hoede. Strahlentherapie, 1930, XXXVI, 727.

The use of roentgen rays in cases of hypertrichosis is definitely contra-indicated. More or less general agreement on this subject has been reached in this country and the majority of Continental physicians is adopting the same stand. Two cases observed by Hoede illustrate the danger of the procedure most clearly. A girl received X-ray therapy at the age of eighteen over the left and right cheek, lips, and lower chin. The doses are given in detail: over the period of one year, 2½ E.D.

were given to the left cheek; during five months 2 E.D. to the right cheek; during five months 2½ E.D. to the lips, and during six months, about 2 E.D. to the lower chin. The filtration was from 2 to 3 mm. of aluminum. In 1928, two years after the exposure, small ulcers formed in several spots on the irradiated areas. In December, 1929, following osteomyelitis of the lower jaw due to an abscessed tooth, an ulcer about 1.7 by 1.9 cm. appeared within an indurated area of the size of the palm of the hand.

The case is analyzed by the author, who concludes that although the doses applied were not excessive, there is no doubt as to the late injury. In his own clinic, in 1919, epilation by roentgen rays for hypertrichosis has been tried out in only one case. This patient was re-examined in 1929 and showed atrophy of the skin, pigmentation, and telangiectasis in the irradiated area on the chin. In her case, exposure to extreme cold in the Winter of 1928-29 had been apparently the causative agent for the appearance of the late injury. This case also demonstrates the fact that late reactions may appear even nine years after the exposure.

ERNST A. POHLE, M.D., PH.D.

Remarks Concerning the Pre-operative Irradiation of the Cervix. A. Mayer. Strahlentherapie, 1930, XXXVII, 311.

The author has been studying the effect of pre-operative irradiation in carcinoma of the cervix on the mortality of surgical intervention. While it is too early to give definite statistical figures, the drop of the mortality rate in casses irradiated before operation was impressive. Roentgen rays and radium combined or either agent alone was used. Six weeks following the first treatment, a re-examination was the deciding factor as to the proper time for operation. If necessary, another treatment was given, and, if six weeks later the condition had not improved, the patient was considered inoperable. Pre-operative irradiation did not, in the author's experience, render the surgical removal of the uterus more difficult.

ERNST A. POHLE, M.D., PH.D.

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Attention is called to the fact that this index is primarily one of titles of papers and names. Titles of papers have been so inverted as to find alphabetical place under their key words. In certain instances, when no key word indicating the subject of the paper appeared in its title, such has been added in brackets. Singular and plural forms of key words have been indexed together; for example, *lung* and *lungs*.

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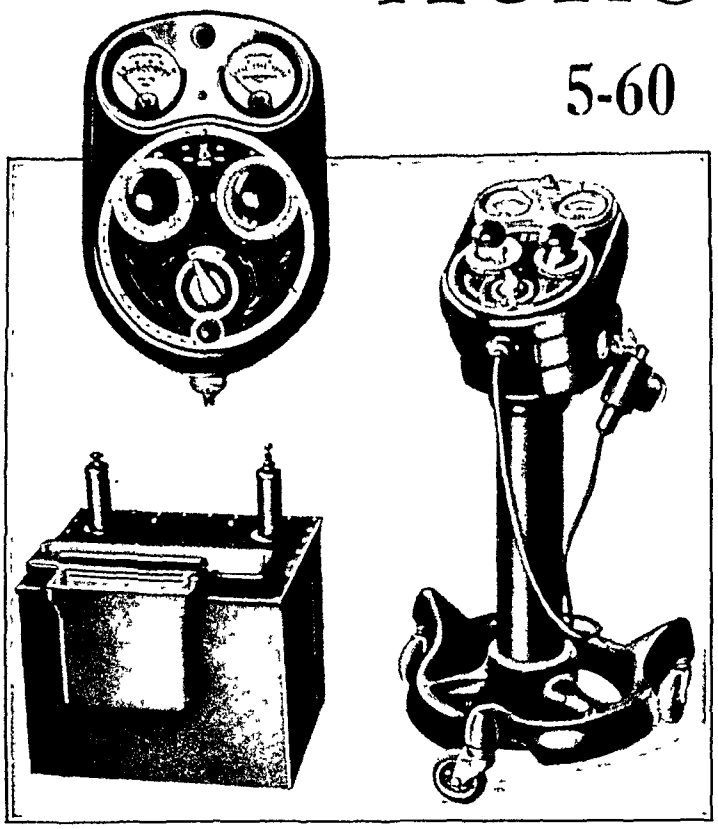
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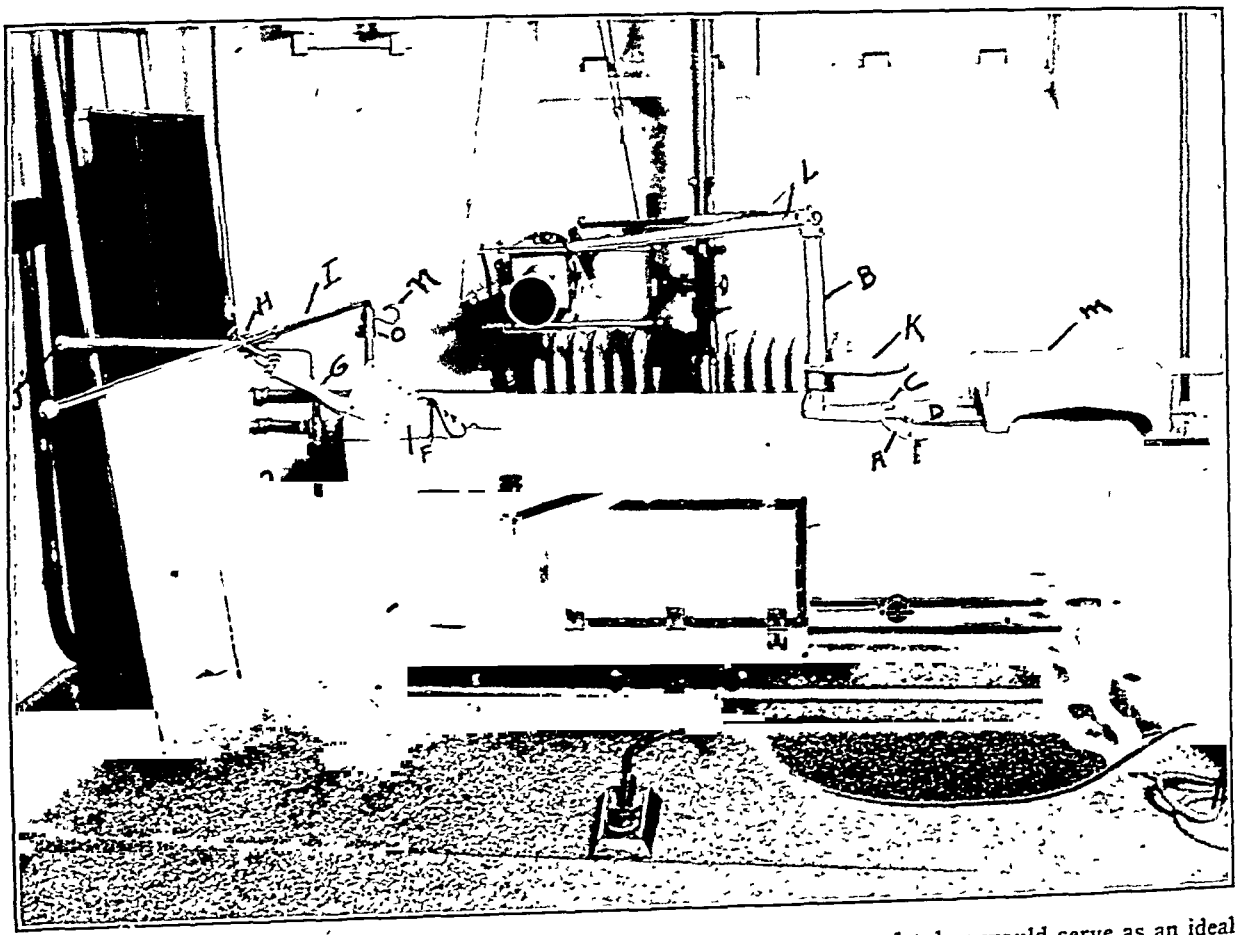
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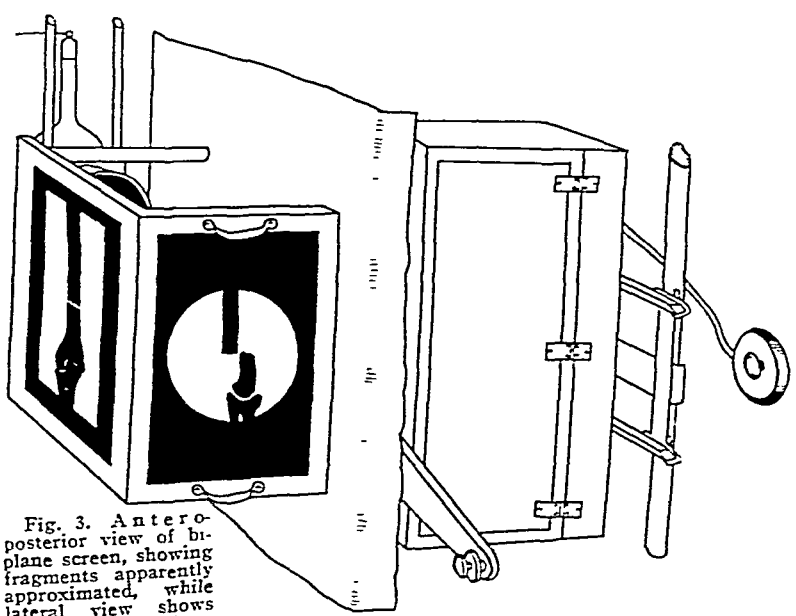


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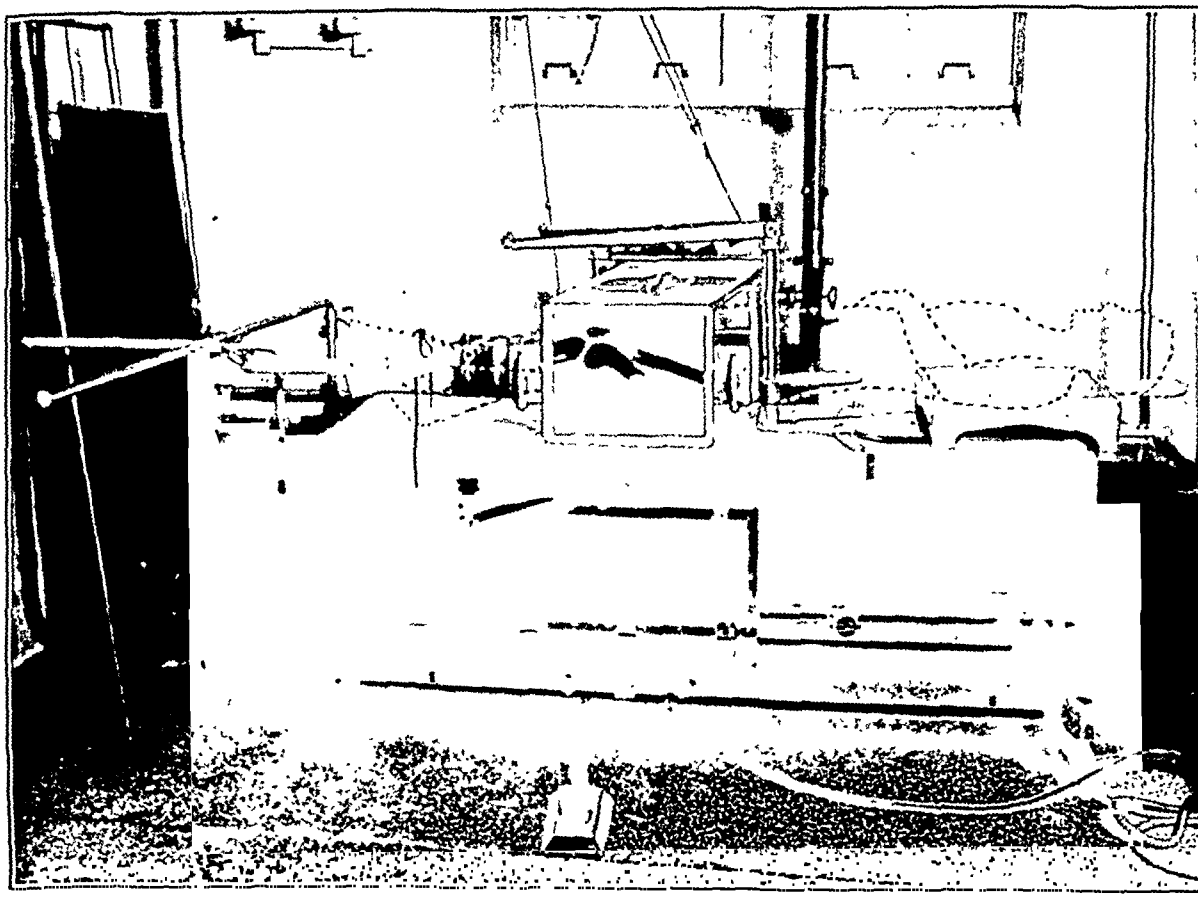


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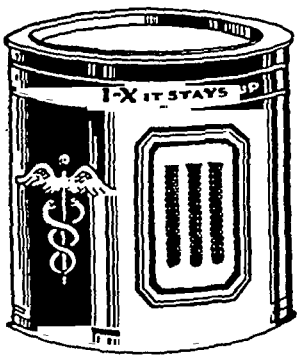
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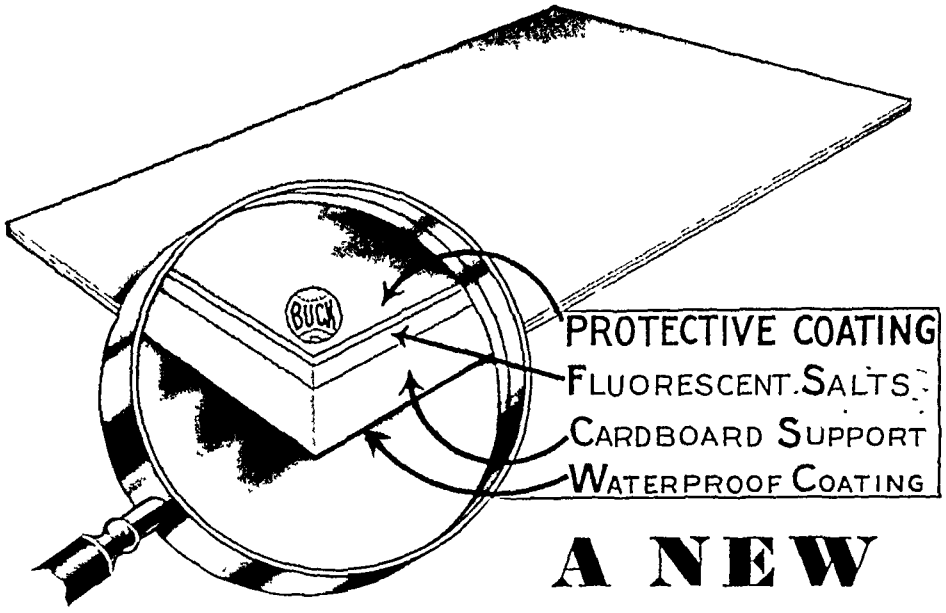
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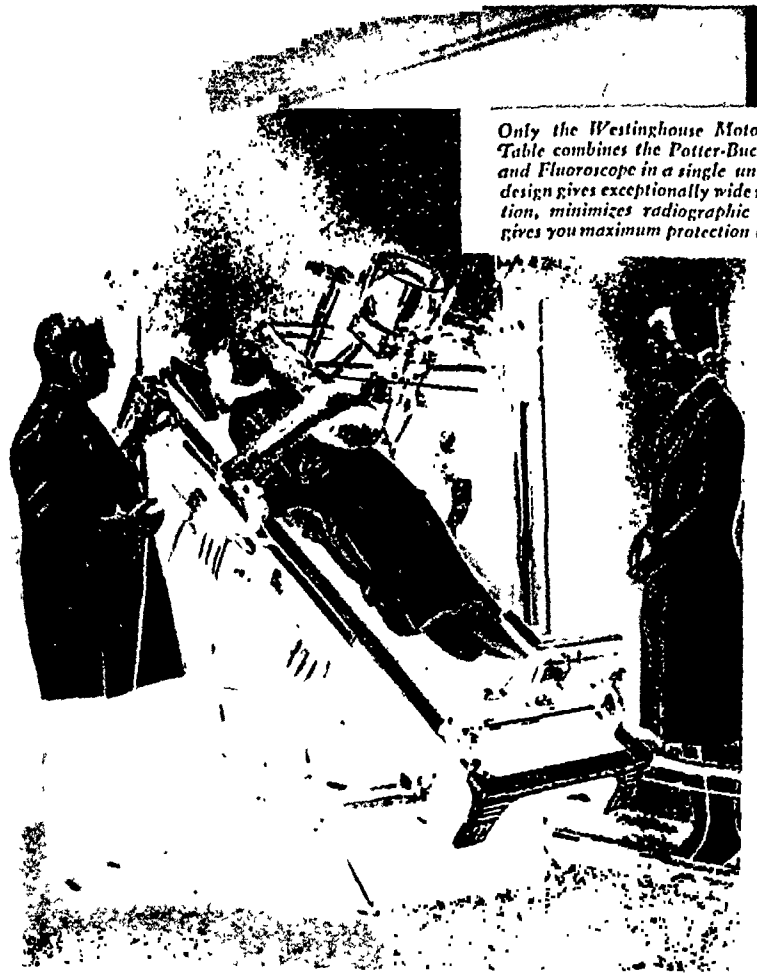
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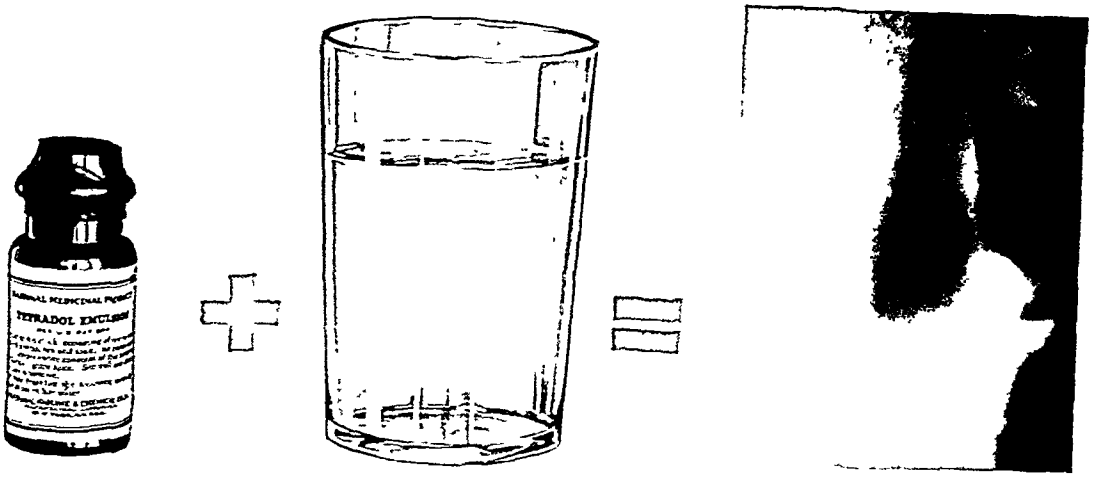
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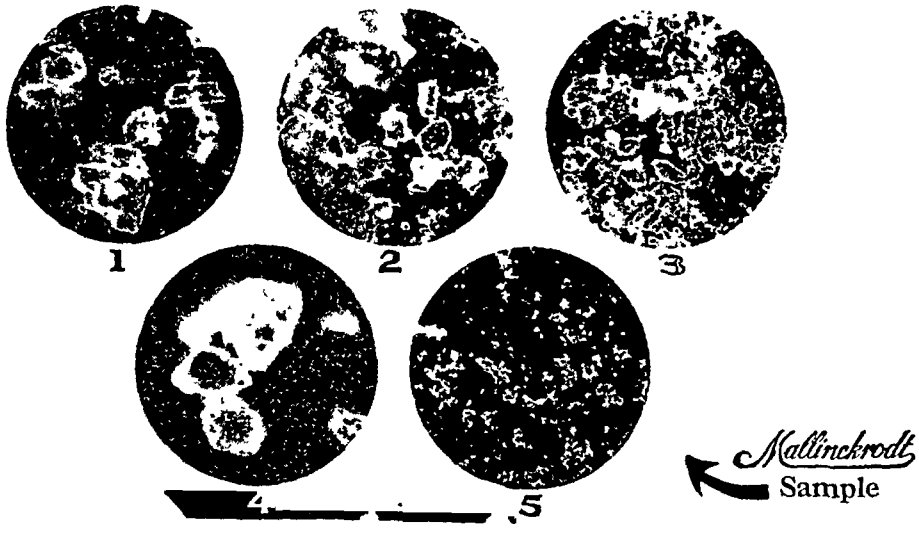
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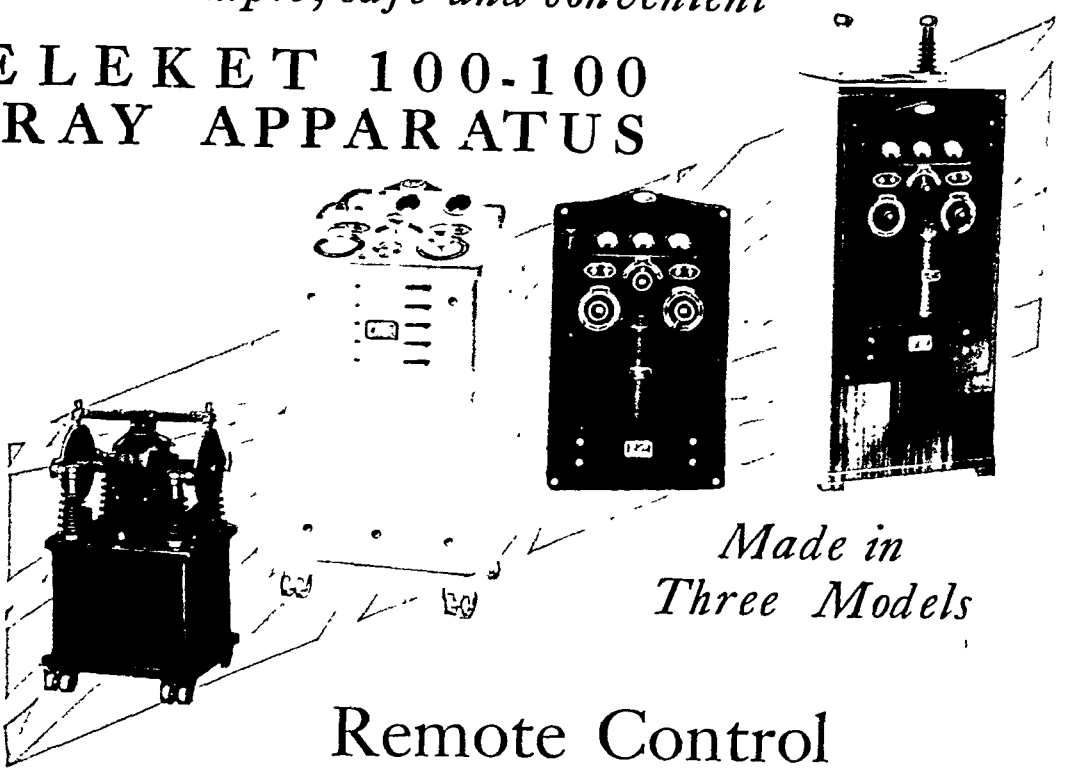
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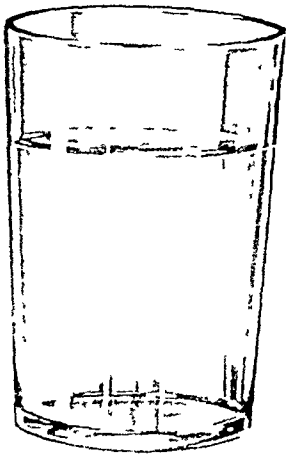
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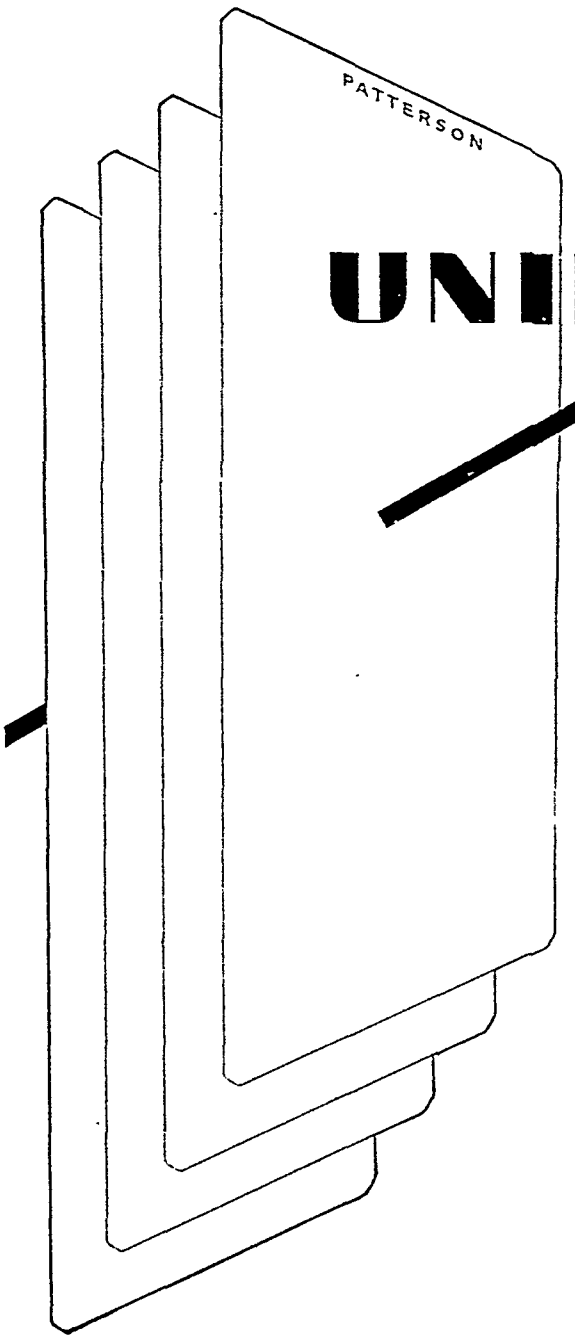
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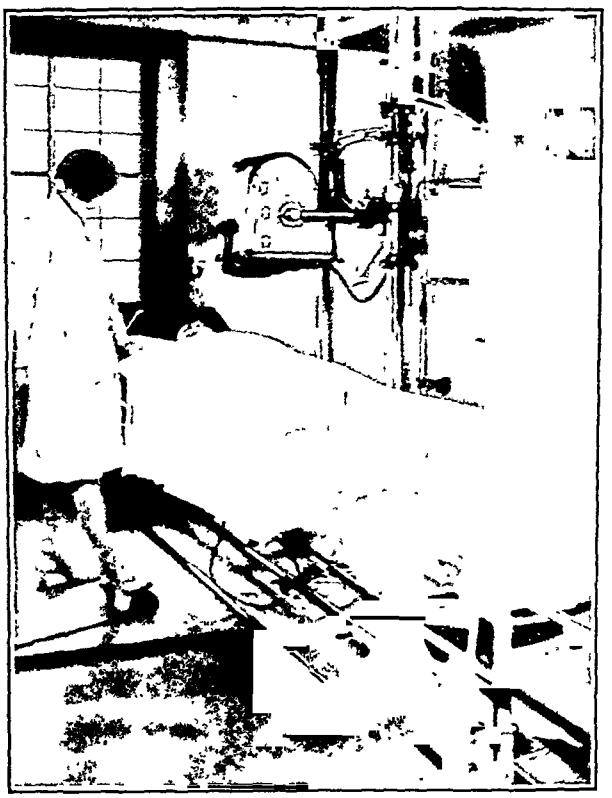
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PUBLISHED BY THE RADIOLOGICAL SOCIETY OF NORTH AMERICA

VOL. XV OCTOBER, 1930 No. 4

A NEW INSTRUMENT FOR MEASURING X-RADIATION[1]

By G. FAILLA, D.Sc., Biophysical Laboratory, Memorial Hospital, NEW YORK

THE fundamental principle of measurement upon which is based the instrument to be described in this paper is a very old one. It is known in physics as the "null," "zero," "compensation," or "balance" method, and is generally accepted as the most satisfactory procedure for certain types of measurement. The well known Wheatstone bridge and potentiometer, used extensively for electrical measurements, are based on this principle. On the other hand, the apparatus as a whole and the component parts in their special functions have not been employed before for similar purposes, at least to the writer's knowledge.

In order to bring out in a simple way the operation of the device, it is well perhaps to start with a mechanical analogy. Everyone is familiar with the weighing of objects by means of a beam balance. Let us analyze the procedure. We wish to determine the weight of, let us say, a coin by means of the simple balance shown diagrammatically in Figure 1. The first thing to do is to check the balance and if it has a "zero error," adjust it so that the pointer P is opposite the zero mark on the dial, when the pans A and B are empty. The coin is now placed in the pan A and, due to its weight, the pointer moves to the left. Then we add a number of weights of known magnitude to the pan B until the pointer is again at the zero mark. Under these conditions the action of the coin on the balance is counter-

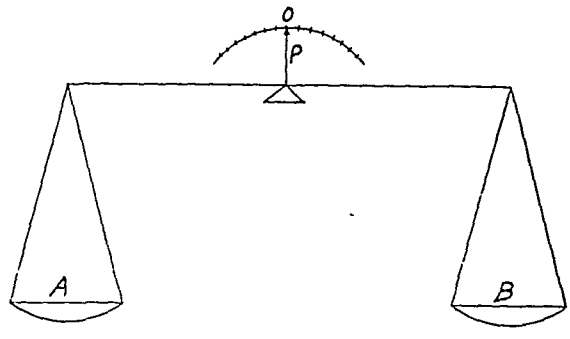


Fig. 1. Simple balance, shown diagrammatically.

acted exactly by the action of the weights. All other factors being equal, therefore, the weight of the coin is equal to the sum of the individual weights placed in the pan B.

The essential elements in this procedure are: (1) A device which is capable of detecting the pull due to the force of gravity acting on a material body, placed in either one of two suitable receptacles; (2) means for adjusting the device to a zero position; (3) a body which, acting on the device, will cause a visible deviation from the zero position, and (4) suitable units of known weight, which, placed in opposition to the first body, will restore the device to the zero position.

[1]Read before the Radiological Society of North America at the Fifteenth Annual Meeting, at Toronto, Dec. 2-6, 1929.

We may now consider how a similar procedure may be employed in a different type of measurement. Let us say that we wish to measure air flow in cubic centimeters per minute. We must have again the four elements mentioned above. Air flow is capable of producing several effects, any of which may be used to actuate the detecting mechanism. Taking pressure as the effect, our detector must be capable of indicating pressure changes. Then means must be provided for setting the indicator, for instance, a pressure gauge, to any predetermined reading to be taken as zero. As the third element we must have something which produces an air current in a pipe, an air compressor. For the fourth element we shall select a suction pump which is calibrated in such a way that, knowing the speed of the pump, the discharge in cubic centimeters is known. The speed indicator in this pump may be calibrated in revolutions per minute or directly in cubic centimeters per minute, since one is related to the other (Fig. 2).

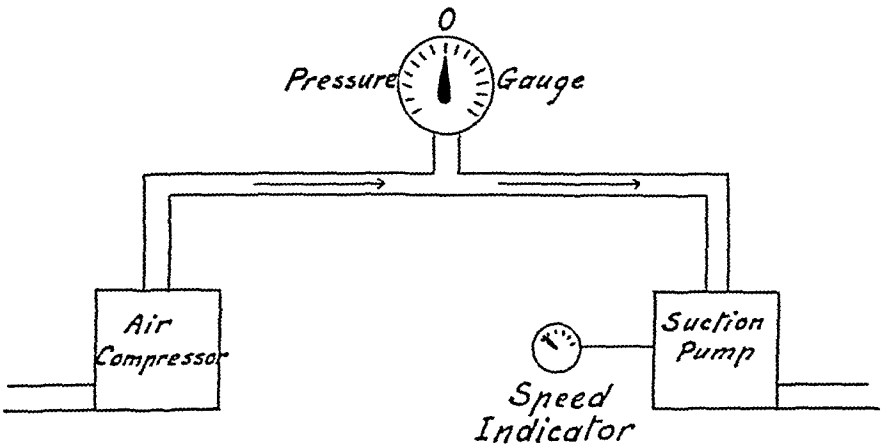


Fig. 2. Hypothetical device for measuring air flow by "balance" method.

The process of measuring the air flow from the compressor is as follows: With both the compressor and suction pump stopped, the pointer of the pressure gauge is adjusted to the zero position. Then the compressor is started. Since air is thus forced into the pipe system the pressure therein will rise and the pointer of the gauge will move. The suction pump is now operated to relieve this pressure and the speed is increased until the gauge pointer is again at its initial zero position. When this equilibrium condition or balance is attained, the amount of air carried out by the suction pump per minute is equal to the rate of discharge of the air compressor. The reading of the calibrated speed indicator, therefore, gives the flow of air through the pipe in cubic centimeters per minute.

In an analogous way one may measure the flow of electrons through a wire, that is, an electric current. Of course, for ordinary purposes this procedure is unnecessary because direct reading instruments (ammeters) are available. But when one wishes to measure a very small current the compensation method is unquestionably the best. Since the measurement of X-rays finally reduces to the measurement of an exceedingly small electric current, a suitable compensation device of this character is very desirable.

In this case also we must have the four elements previously mentioned. On account of the small amount of energy available with a minute electric current, the detector element must be very sensitive. Therefore, of the ordinary available devices only elec-

trometers (of the quadrant, quartz fiber, or gold leaf type) are suitable. It is well known that the three-electrode vacuum tube

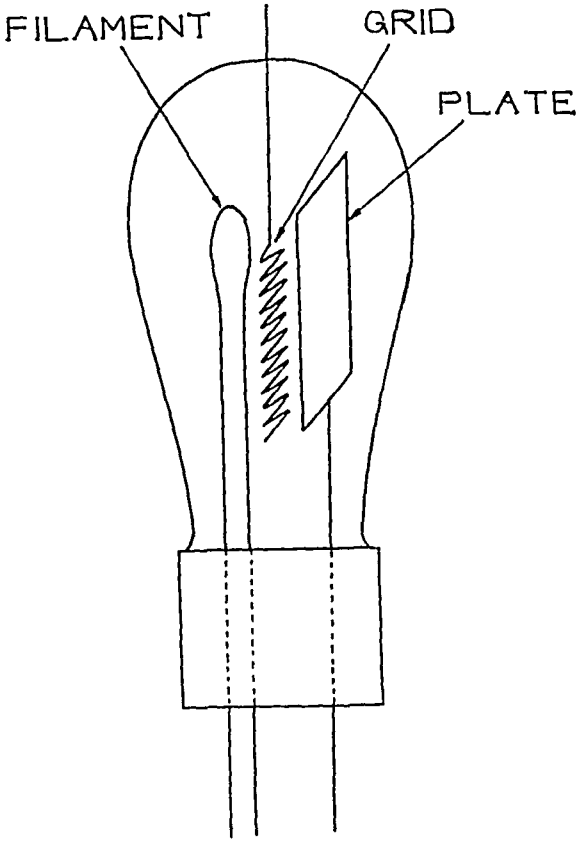


Fig. 3. Three-electrode vacuum tube, shown diagrammatically.

used in radio reception is capable of detecting very small electrical changes, and, therefore, it should be possible to use a device of this sort for our purpose. The problem, however, is not so simple as it appears, and many practical difficulties had to be overcome before a really satisfactory vacuum tube detecting device was constructed.

To simplify the description of such a device it is well perhaps to explain briefly the operation of the three-electrode vacuum tube used in radio sets. Figure 3 shows such a tube schematically. The filament consists of a metal wire which is heated by passing a current through it and is used in the operation of the tube as a source of electrons. This is analogous to the filament of a Coolidge tube. Opposite the filament is a metal plate which corresponds to the target of an

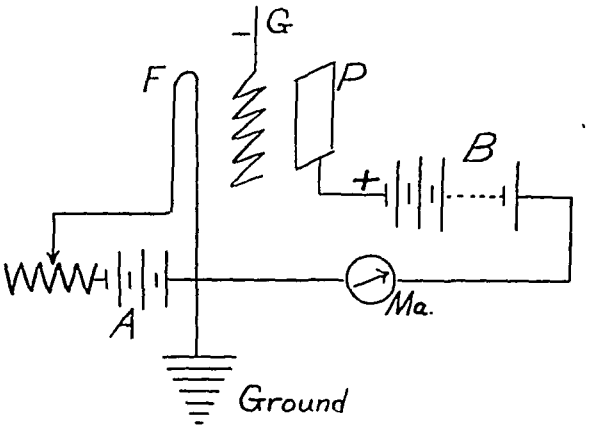


Fig. 4. Simple vacuum tube detector circuit.

X-ray tube. Between filament and plate is suspended a "grid" consisting of metal gauze. The purpose of this grid is to control the flow of electrons from the filament to the plate.

In actual operation the plate is kept at a positive voltage with respect to the filament by means of a suitable battery, or otherwise. Then the electrons liberated by the hot filament are attracted by the plate and travel toward it. Since the intervening grid is a wire mesh with wide spaces between the wires, most of the electrons can pass through and reach the plate. However, the grid is insulated from the other elements of the tube and may be charged at will to any desired potential by means of a suitable battery. If, for instance, it is charged negatively, it will now repel the electrons emitted by the filament and will prevent some or all of them from reaching the plate. If the grid terminal of the tube is left disconnected, the grid will collect some electrons from the filament and will assume a certain negative potential the magnitude of which depends on factors which we need not consider here.

Figure 4 shows the simple circuit in which this is brought about. A is the battery

which heats the filament and B the battery which keeps the plate at a positive potential. When electrical equilibrium has been established the grid assumes a negative potential with respect to ground, and the plate current, which measures the flow of electrons from the filament to the plate, assumes a certain definite value. This current may be measured by a milliammeter, Ma, in the plate circuit, as shown in Figure 4. If, now, the potential of the grid is changed, the value of the current will also change and the milliammeter will read differently. Very little energy need be supplied to the grid to keep it at any desired voltage. The resultant change in plate current involves a considerable change in energy but this is supplied by the B battery. It is this property of the vacuum tube which makes it so suitable for radio reception. The minute amount of electrical energy collected by the antenna travels to the grid of the tube and changes its voltage. This, in turn, causes changes in the plate current of greater magnitude, and thus the "signal" is amplified.

Now we may consider the circuit of Figure 5, which is the same as that in Figure 4

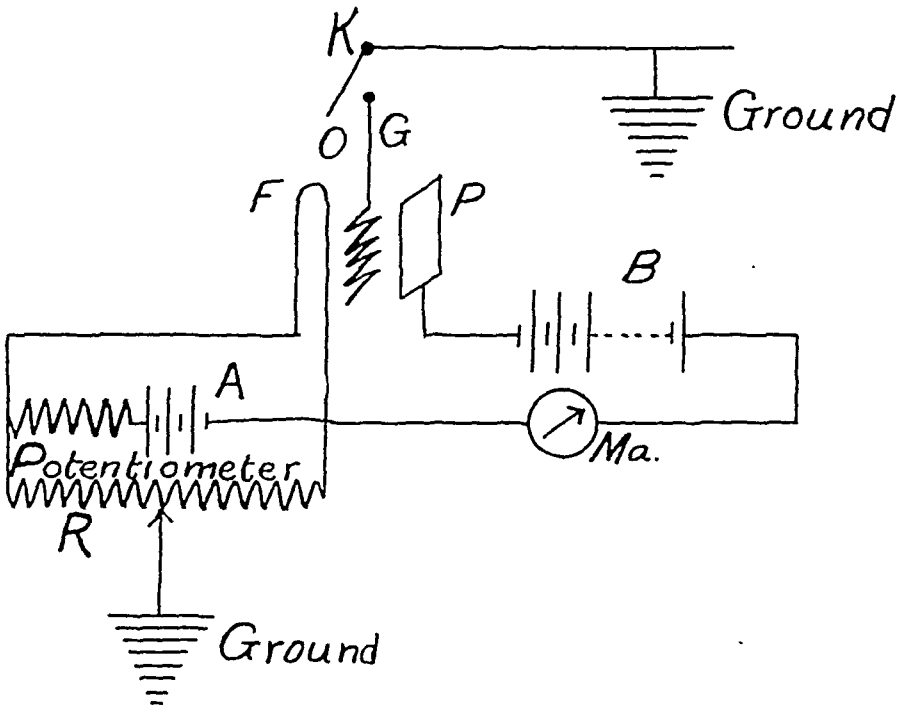


Fig. 5. The same circuit as shown in Figure 4 with the addition of a potentiometer, R, and a grounding key, K.

with the addition of a potentiometer, R, and a grounding key, K. The potentiometer is for the purpose of changing the potential of the filament with respect to ground in such a way as to make the potential which the grid would normally assume identical with ground potential. When the proper adjustment has been made, the key, K, may be closed without changing the plate current. In practice, this adjustment is made by shifting the sliding contact on R until the milliammeter gives the same reading whether the grounding key is open or closed. If we use the vacuum tube as the indicator of electric pressure, this operation corresponds to the zero adjustment of the pressure gauge in the air flow problem discussed above.

In Figure 6 we have the circuit of Figure 5 with the addition of an ionization chamber, M.C., which corresponds to the air compressor and provides the electric current to be measured. One electrode of this chamber is charged positively by connecting it to a battery, as shown. The other electrode is connected to the grid of the vacuum tube. If the chamber M.C. is exposed to X-rays, an ionization current will pass through it and will travel to the grid. This will change the potential of the grid and consequently the plate current differs from its initial value. With the polarities as shown in the figure, the plate current will be larger when the ionization chamber is exposed to X-rays. We need now something analogous to the suction pump in the air flow measuring device, in order that the milliammeter reading may be restored to its initial or "zero" value. Just as an air current is produced by the motion of molecules, we may think of an electric current as the migration of electric charges. Since there are positive and negative charges we may have an electric current produced by the motion of either type of charge. The current which flows from the chamber M.C. to the grid of the vacuum tube in Figure 6, may be thought of as the migration of positive charges from the chamber to the grid. Since positive and negative charges of equal magnitude neutralize each other when they come together, the effect of the current from M.C. may be compensated by the effect of a second current which will carry negative charges to the grid. When complete neutralization occurs at the grid the milliammeter pointer returns to its "zero" position and the two currents are of equal magnitude. Accordingly, we need a device which will permit us to send to the grid the proper compensating current.

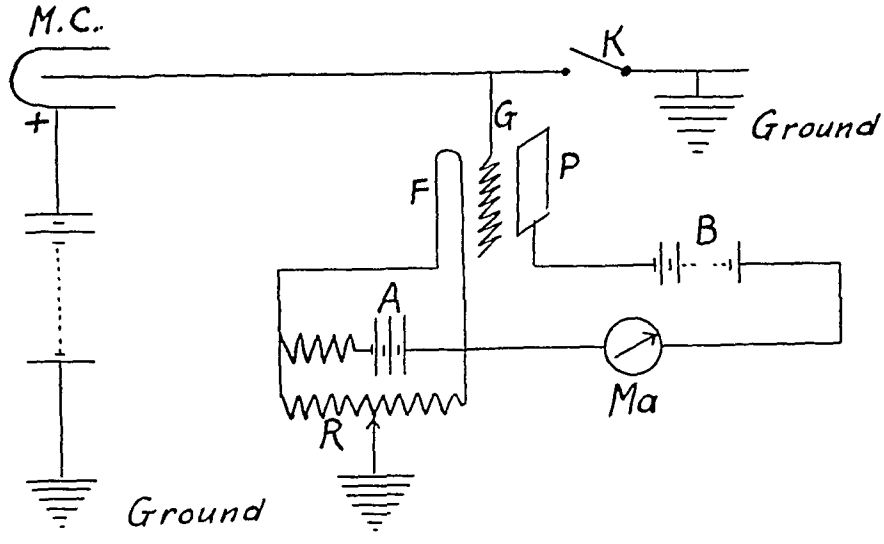


Fig. 6. The same circuit as shown in Figure 5 with the addition of an ionization chamber, M.C., which provides the electric current to be measured.

Small electric currents can be produced, of course, in a great many different ways, but for our purposes it is not sufficient to produce a current which will balance the X-ray ionization current. We must know in addition the magnitude of the balancing current. Since the two currents are of the

same magnitude, it is just as difficult to measure one as the other. Accordingly, we must find some way of indicating indirectly the magnitude of the compensating current

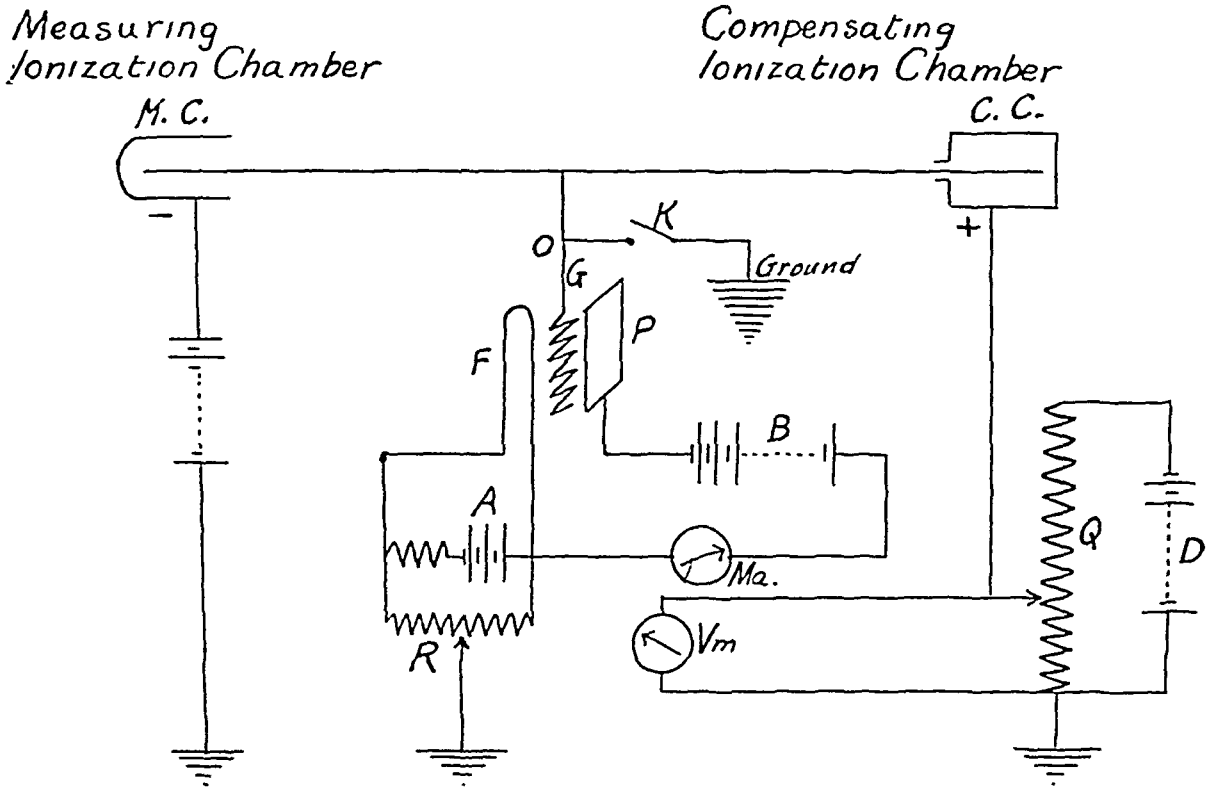


Fig. 7. The connections for the compensating ionization chamber, C.C., in its relation to the system shown in Figure 6.

on a rugged instrument. This can be done in any one of several ways but the most satisfactory arrangement we have found is to use an ionization chamber with some radio-active material. If the radio-active substance is sealed in an air-tight chamber of suitable design, the ionization current produced will depend only on the voltage applied to the chamber. Therefore, having once determined the relation between applied voltage and resultant ionization current, it is necessary later only to measure the applied voltage in order to know the magnitude of the current. This can be done simply by means of an ordinary voltmeter.

Figure 7 shows the connections for the compensating ionization chamber, C.C., in its relation to the system of Figure 6. A potentiometer, Q, is provided to supply the voltage to be applied to the chamber C.C. The voltmeter, Vm, records this voltage, and corresponds to the speed indicator in the air flow analogy. Knowing the value of the applied voltage, the magnitude of the compensating current can be determined from a calibration curve such as shown in Figure 8. In this curve the current is expressed in electrostatic units, but, of course, it can be expressed in any units. For practical purposes it is preferable to provide a scale on the voltmeter, which indicates directly the value of the compensating current in the desired units. Such a scale can be graduated easily by means of the calibration curve of Figure 8.

With an arrangement of this sort it is im-

portant to know whether the calibration of the compensating chamber remains constant over a reasonably long period. As a matter of fact, unless the calibration does remain constant the instrument as a whole is not of great practical utility. For this reason a thorough investigation of this problem has been made.

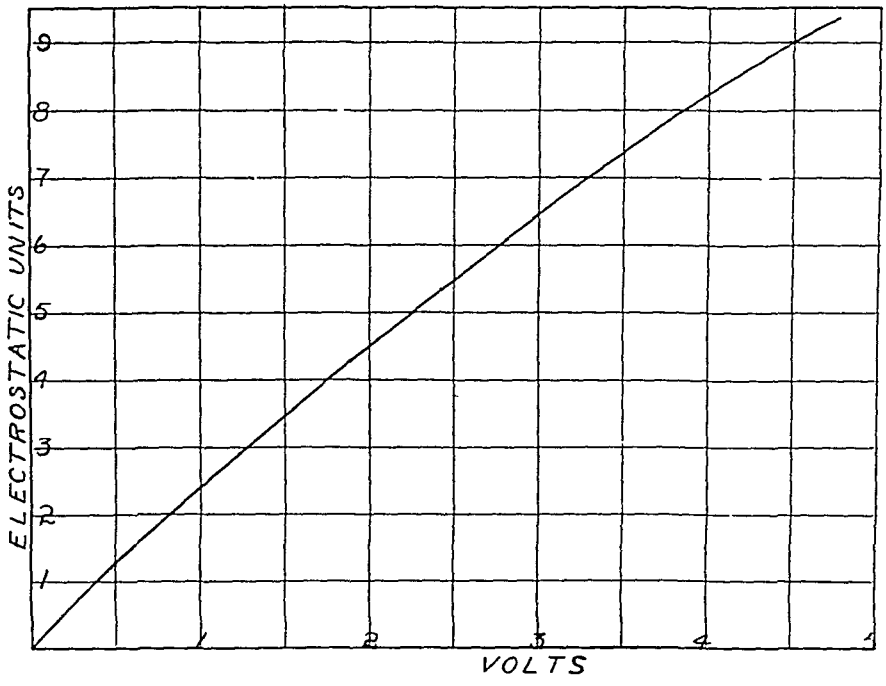


Fig. 8. Calibration curve of a radio-active compensating chamber.

We have found that the design of the compensating chamber is of considerable importance. However, a chamber with concentric cylindrical electrodes properly insulated and provided with "guard rings" is very satisfactory. We have used radium as the radio-active material, since it has a long life and is easily available. The radium salt is deposited on one or both of the cylindrical electrodes and the chamber is sealed air-tight to prevent loss of radon. After sealing, the radio-activity of radium increases for about a month and then remains practically constant for a considerable time. The ionization within the chamber remains constant at least for several months, according to measurements which we have made. We can think of no reason why any considerable change should occur in a period of a few years. The amount of radium required to produce a current of the proper magnitude for ordinary X-ray measurements is very small and its cost is negligible.

The operation of the measuring device is independent of the design of the ionization chamber used for the measurement of X-rays. That is, the instrument is capable of measuring a very small unidirectional current, no matter how it is produced; therefore, any type of ionization chamber or source of small current may be used. However, for practical X-ray measurements in the clinic it is preferable to use a rather large chamber, which produces a fairly large current with ordinary beam intensities. This permits the calibration of the X-ray machine according to the radiation output, so that the radiologist may duplicate treatments at any time. In the opinion of the writer the use of a small ionization chamber, which is

kept on the patient during the treatment, is not desirable (1). For practical work in the X-ray department we have designed the chamber shown schematically in Figure 9. It consists of a lead-lined brass shell of the shape shown, enclosing three parallel plane electrodes. These are made of thin animal skins ("drum heads") stretched over suitable rings and coated with India ink. The separation between the plates is 2 cm., and, therefore, saturation current may be obtained without the use of high voltages. The beam of X-rays to be measured travels at right-angles to the electrodes and traverses them. Since they are very thin and of organic nature, they absorb little radiation of the hardness usually employed in radiotherapy. Limiting diaphragms of different diameters may be used with the chamber to vary the size of the X-ray beam admitted into the chamber. A large opening is provided at the emergence side of the chamber so as to permit the beam to pass through without striking any part of the chamber except the three electrodes.

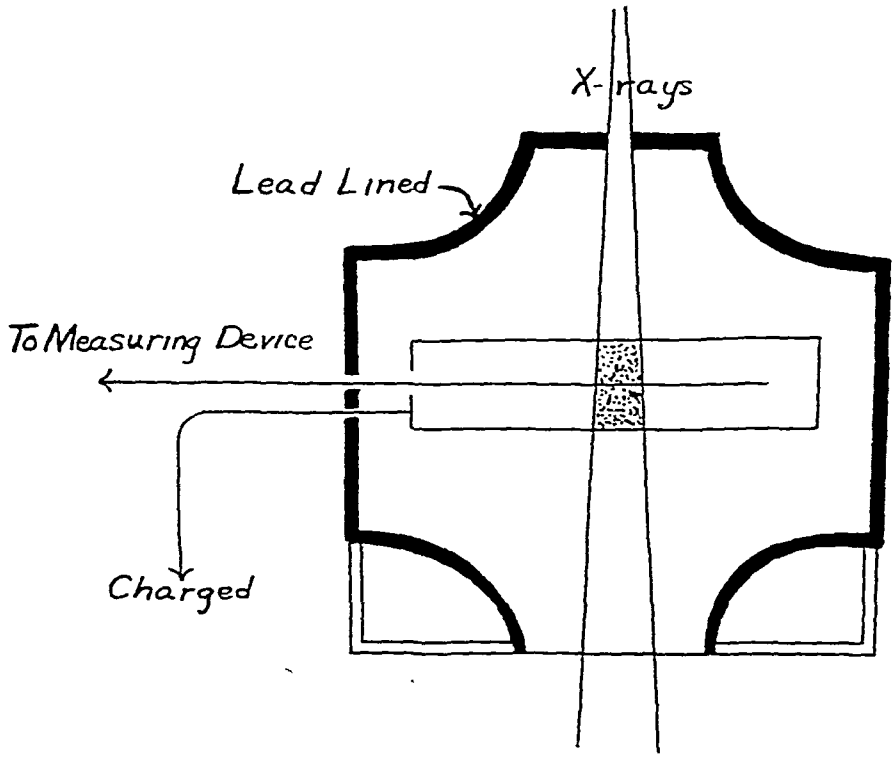


Fig. 9. "Drum head" ionization chamber intended for routine measurements in the X-ray clinic.

A comparison of the ionization produced in this chamber with that produced in a "standard open air chamber" (2) when the same beam of radiation is used, is given in Table I. In this experiment the X-ray tube voltage was about 185 K.V., and the copper filter was varied from 0 to 2.5 millimeters. From the ratios given in the last column of the table, it will be seen that the two chambers agree closely throughout the wide range of filtration used. It may be mentioned here also that the "drum-head" chamber may be used as a standard chamber within ordinary limits. That is, the intensity of an X-ray beam may be determined in r per minute, without previous calibration. For this purpose the "ionized volume" is determined by

the area of the diaphragm and the distance between the outer electrodes. For very hard X-rays no appreciable error is introduced by this procedure. For high voltage X-rays filtered by a small thickness of copper the direct r per minute determinations with the drum-head chamber are 3 or 4 per cent too low.

Employing the "balance method" of measurement, the electrode of the ionization chamber which is connected to the measuring instrument proper is at zero potential with respect to ground when the reading is taken. On this account the cable connecting the chamber to the vacuum tube device need not have extremely high electrical insulation. We have found that in practice ordinary "lamp cord" serves the purpose very well. Furthermore, the length of the cable does not influence the reading of the instrument. We have used a cable one hundred feet long which permits us to calibrate every machine in the X-ray Department with the instrument in a fixed position. With a measuring device of the electroscope type, however, the readings are dependent on the length of the cable used and the insulation must be as high as possible. A satisfactory flexible cable for this purpose is difficult to make since it must be highly insulated, must have no air spaces where ionization may take place, and must have a constant electrical capacity in any position. It may be said, in fact, that the cable is the weakest point of all electroscope devices. In the case of our instrument this difficulty has been eliminated completely.

From the point of view of constancy of calibration, the instrument described here possesses distinct advantages. In the electroscope type of instrument the calibration may change, due to variations in the following factors: (1) sensitivity of the electroscope (or electrometer) proper; (2) electric capacity of the electroscope, cable, and ionization chamber; (3) electrical insulation on account of age, dirt, or humidity. Accordingly, for accurate work it is necessary to check the calibration of the instrument with radium every time that it is used. In the case of our instrument the calibration is influenced by only two factors: (1) changes in the radium compensating chamber, and (2) variations in the voltmeter calibration. Changes of appreciable magnitude in these two parts of the apparatus are very unlikely. Check measurements made with radium over a period of several months show that readings can be duplicated from day to day within 1 per cent. Furthermore, any part of the instrument may be replaced easily without the necessity of calibrating the apparatus as a whole. In other words, the compensating and measuring chambers and the voltmeter can be calibrated individually as often as desired. Insofar as the vacuum tube system is concerned any part of this may be replaced without affecting in the least the calibration of the instrument. Since standard tubes and parts are used, they may be bought in any radio shop at small cost.

TABLE I

Filter (Mm. Cu)	Air Chamber	Drumhead Chamber	Ratio
0	935	931	0.997
0.039	412	408	0.995
0.078	289	284	0.982
0.16	183.3	182.5	0.997
0.32	118.4	118.6	1.002
0.64	70.7	70.9	1.003
1.28	38.2	39.1	1.024
2.50	16.7	17.5	1.046

Only two manual operations are required in making measurements with this device: (1) "setting the zero," and (2) compensating the current produced in the X-ray ionization chamber. In either case the proper adjustment is made by the turning of a knob.

It will be noted, however, that the device, as described so far, embodies some batteries which naturally require attention from time to time. While the use of batteries does not introduce serious difficulties, it is neverthe-

less a drawback. For this reason we have developed an alternating current instrument in which no batteries at all are used. It is necessary only to connect the device to a source of alternating current and all the required voltages are provided by a suitable "power pack," as in the so-called "all electric" radio sets.

The behavior of this instrument in actual operation, as well as the soundness of the principles involved, enables us to say that it fulfills all requirements demanded by routine measurements in the radiological clinic. A very critical attitude has been maintained throughout the long period of development, looking for faults and sources of error. Many difficulties have been encountered but no insurmountable ones. The instrument has been used in our laboratory for some time both for experimental work and routine measurements, and has been very satisfactory. A similar instrument has been in operation for the daily measurement of radon during the last few months. It has maintained its original calibration with remarkable constancy, so that the discrepancy in the readings given by our radium standard has been consistently less than 1 per cent during this period.

The writer takes pleasure in expressing his indebtedness to his assistants, Mr. George D. Barclay, Mr. Edwin Lobley, and Mr. Leonidas Marinelli for their wholehearted and valuable co-operation in the construction and testing of the instrument.

SUMMARY

A. A new type of X-ray measuring instrument is described, in which use is made of the well-known balance or compensation method of measurement.

(1) A vacuum tube device is used as the "balance detector."

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B. The instrument possesses several distinct advantages.

(1) Extremely high electrical insulation is not necessary.

(2) The length of the cable joining the ionization chamber to the measuring device proper does not influence the readings. Therefore a long flexible cable can be used, permitting the observer to be in a separate room at any desired distance from the X-ray machine.

(3) The instrument can be calibrated to read directly in roentgens per minute (no stop watch is required).

(4) It has a wide range, permitting the measurement of X-ray beams of very different intensities.

(5) It has a high sensitivity combined with stability and ruggedness.

(6) The use of radium or other long-lived radio-active material in the compensating ionization chamber insures an unusual permanence of the calibration.

(7) No delicate apparatus is embodied in this instrument.

(8) The vacuum tubes and other "radio" parts used can be replaced (at small cost) *without affecting the calibration* of the instrument. These parts are readily obtainable throughout the country.

(9) Simplicity of operation.

C. A new ionization chamber is described briefly in this paper.

(1) It permits the determination of the X-ray beam intensity directly in roentgens per minute without previous calibration, over a considerable range of hardness.

(2) A potential of a few hundred volts is sufficient to produce saturation in this chamber with all practical beam intensities.

D. The measuring device proper is capable of determining the magnitude of a very

small, unidirectional, electric current. Accordingly it may be used to measure anything which can be made to produce an electric current. In addition to X-rays, by suitable accessories, it can measure—

(1) Radio-active substances and their radiations;
(2) Visible light;
(3) Ultra-violet light.

E. The instrument described in this paper has passed the experimental stage and has been in actual operation for a considerable time. Its practical utility at the Memorial Hospital has been definitely established.

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(1) FAILLA, G.: The Measurement of X-ray Dosage by Physical Means. RADIOLOGY, October, 1929, XIII, 293.
(2) FAILLA, G.: Criteria for the Design of a Standard Ionization Chamber. Am. Jour. Roentgenol. and Rad. Ther., January, 1929, XXI, 47.

DISCUSSION

DR. LAURISTON S. TAYLOR (Washington, D. C.): As Dr. Failla began to have one slide after another put on the screen, they grew apparently more and more complicated until my hair almost stood on end at the prospect of what it would be if he kept up much longer. But I do not believe most of you realize how extremely simple this final circuit is, compared to the corresponding vacuum tube circuit used by one or two foreign instruments which employ the vacuum tube for their energy-measuring instruments. The particular advantage of this circuit, as I see it, from a practical point of view and as Dr. Failla pointed out, is that it is null reading, thereby making it possible to use almost any old kind of vacuum tube in the detector circuit. So that, if your technician drops a hammer on the vacuum tube, all you need to do is to go home and take a tube out of your radio circuit and you are ready to go on again, whereas, with the other instruments, you have to send over to Europe for a tube—possibly have to have the tube calibrated—and be without your instrument for some time. From a practical point of view, the importance of that feature is very hard to exaggerate.

Dr. Mutscheller has talked about a new measuring device, and Dr. Failla has talked about two more, and in a little while I will have a couple more to talk about, so it may sound kind of discouraging to the people here. We are talking about these things and we keep on talking about them, and you begin to wonder where we are going to stop or if they are any good to begin with. The reason is this: the development of these new chambers does not necessarily mean that there is any fundamental difficulty involved in our intensity measurements. The thing is, that only by developing new chambers, many of which will be superseded by others as time goes on—only by doing that kind of work can we arrive in the end at something which is thoroughly practical and useful. So that if the physicists are going to keep on talking about such apparatus, as they will for some time, don't get discouraged, because in the end maybe we will have something that is pretty usable.

Another very important point which Dr. Failla's paper has brought out is this question of making instantaneous measurements, for his circuit is adjusted until you determine by a single reading the intensity of the beam. The reading does not need to be extended over a long period of time; there is not a step which is involved; you do not need to bring time into your calculations; it reads the intensity of the beam at a given instant, and I think that only by such readings as that are we going to get away from a very confusing point, the distinction between the X-ray beam intensity and the X-ray dose. This question has been under argument for a number of years. The medical doctor thinks in terms of "dose," and when you try to tell him anything about a dose, you really find that you

less a drawback. For this reason we have developed an alternating current instrument in which no batteries at all are used. It is necessary only to connect the device to a source of alternating current and all the required voltages are provided by a suitable "power pack," as in the so-called "all electric" radio sets.

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THE EARLY RECOGNITION OF GASTRIC ULCER AND CARCINOMA AS REVEALED BY ROENTGEN-RAY STUDIES[1]

By MAURICE FELDMAN, M.D.

Assistant Professor of Gastro-enterology, University of Maryland, BALTIMORE

From the Gastro-enterological Clinic of the Department of Medicine, University of Maryland, Baltimore

THE roentgen diagnosis of a gastric lesion depends principally upon the presence of a filling defect. In a large proportion of ulcerative and carcinomatous lesions, this pathognomonic sign is present; but occasionally, especially in early cases, no filling defect may be observed, even though the patient may present definite clinical evidence of gastric disease. These unusual types require most careful study and at times frequent roentgen examinations become necessary, in order that the conclusions gained both by X-ray and clinical findings may be correlated and the diagnosis be more definitely established. The diagnosis of a gastric lesion with the characteristic filling defect presents no difficulty and is not considered in this paper.

Insufficient attention, however, has been directed to the recognition of gastric disease in which filling defects are not revealed. This type of stomach usually appears normal and not infrequently the diagnosis remains uncertain from an X-ray point of view. Although it is well recognized that filling defects are the only positive indications of gastric disease, secondary roentgen signs must also be considered as an additional aid in arriving at an early diagnosis. There are many secondary signs, but the most important are (1) an absence or diminished peristalsis in the area involved, and (2) spasm.

In serial roentgenography with films taken at short intervals, the stomach appears to alter its contour; and it may be observed that the peristaltic indentations become deeper and shallower, coincident

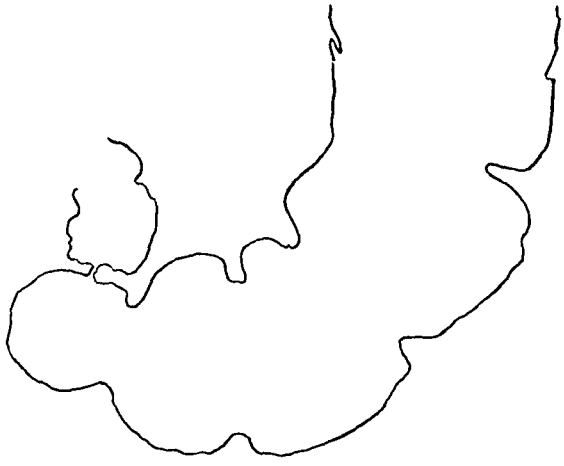


Fig. 1-*A*. Tracing of stomach from roentgenogram, showing the normal peristaltic waves.

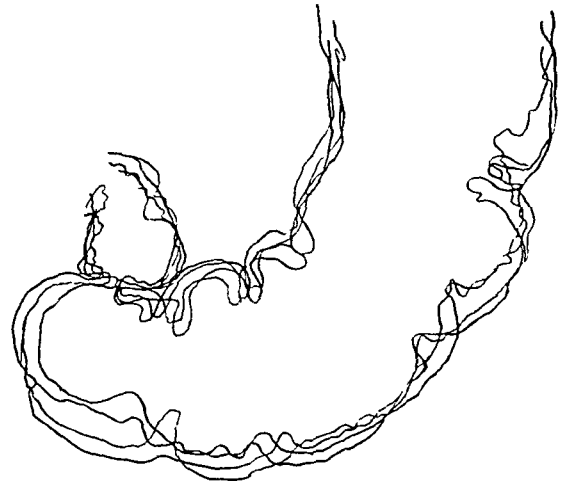


Fig. 1-*B*. Superimposed tracings of a normal stomach roentgenogram.

[1]Read before the Radiological Society of North America at the Fifteenth Annual Meeting, at Toronto, Dec. 2-6, 1929.

apparently with systolic and diastolic changes in the musculature of the entire organ (1). The normal peristaltic waves as observed fluoroscopically, apparently take their origin in the fundus and travei

volvement of both curvatures, with diminution of peristalsis.

The fixed appearance of the stomach when constantly present in the same position is usually the result of a gastric lesion.

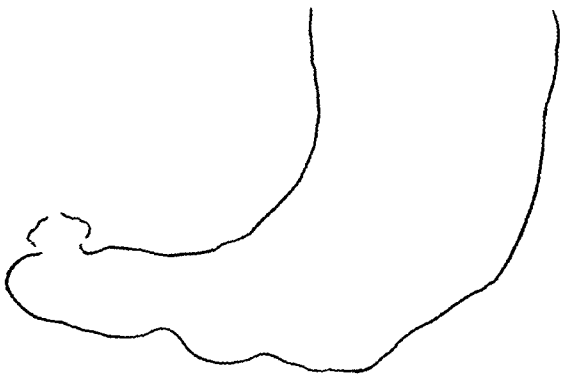


Fig. 2-*A*. Tracing of stomach, showing the stereotyped or fixed appearance; note the diminished peristalsis and an abnormal roundness of the lesser curvature.

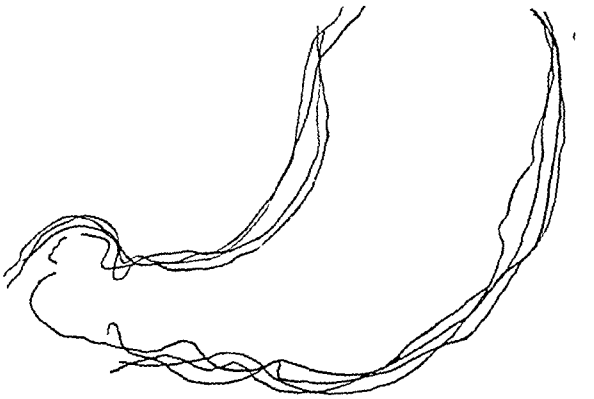


Fig. 2-*B*. Same case, with roentgenograms superimposed, illustrating the absence of peristaltic waves.

toward the pylorus. According to Alvarez these peristaltic waves appear as ripples originating from the region of the cardia, travelling in different directions toward the pylorus. When serial roentgenograms are superimposed a change in each roentgenogram, revealing different phases of peristalsis, is observed. An absent or diminished peristalsis or a break in the peristaltic wave is presented in the films in the form of a fixed appearance of the curvatures of the stomach. This fixation, however, is more especially observed on the lesser curvature. When films revealing gastric lesions are superimposed, there is an absence of the different phases of peristaltic waves, presented on the films in the form of a stereotyped or fixed appearance.

This condition is observed in various types, depending upon the lesion present: (1) a straight line appearance, usually noted on the lesser curvature; (2) a roundness of the lesser curvature; (3) a possible in-

Kuttner terms the straight line appearance the cross-bar (Riegel) sign of Frankel. He observed this sign in one-fifth of twenty-six cases and attaches great importance to it as an early sign of gastric disease.

There can be no question but that in many instances in which organic gastric disease is at hand, the roentgen examination of the stomach being essentially negative, this fixed appearance is noted. This sign indicates changes usually due to carcinoma or ulcer and is usually observed in the early stage of these affections.

Polygraphy, a method of obtaining several exposures in rapid succession on one film, is described by Bernstein (4) as an ideal means to determine the arrest of peristalsis, which is said to be of considerable diagnostic aid in the localization of ulcers. This method although valuable is not always practical. In several instances we have found the shadows of polygraphy confusing and, due to the ease with which the



Fig. 3-*A*. Roentgenogram showing the stereotyped or fixed stomach; note the roundness of the lesser curvature. Tracings of this case are illustrated in Figures 2-*A* and 2-*B*.



Fig. 3-*B*. Three months later, showing a carcinomatous filling defect, confirmed by operation.

stomach tracings can be made from a series of films and be superimposed, we consider the latter method preferable for the study of peristalsis.

The stereotyped, fixed, or straight line appearance of the stomach curvatures must be recognized as a fairly constant sign of carcinoma and ulcer. The extensive stereotyping is usually observed in carcinoma, most frequently involving the cardia of the stomach, while the straight line appearance due to a break in the peristaltic wave is not uncommonly the result of an ulcer, but may however also be produced by carcinoma. These signs were constantly present in a large series of films of these affections, taken in our clinic. The fluoroscopic examination does not reveal these changes in detail and the findings are usually indefinite, but when they are observed at times, cannot be relied upon until corroborated by a series of films.

The late changes of carcinoma presenting large filling defects, palpable masses, and obstruction are not considered in this study. Since early recognition of this disease is important as a means of a possible operative cure, any sign which will aid in the recognition of this condition must be considered of the greatest importance. The sign described above must be considered as an aid in this direction.

In early carcinoma both curvatures may become involved, revealing an absent or diminished peristalsis, with the typical stereotyped or fixed stomach. The stomach is usually situated high under the left diaphragm, showing no filling defect, and may appear smaller than normal. The emptying time is usually rapid but may be normal in some instances. No palpable masses can be detected at this stage of the disease. However, as the condition progresses after some time, a filling defect may be detected in the cardia of the stomach, eventually involving the lower end of the esophagus and the cardio-esophageal opening.

In the ulcerative type the affection usually occurs on the lesser curvature and the break in peristalsis is not so marked. In this form the typical straight line effect is revealed, being constantly present on all the films.

Persistent spasm is a frequent finding in

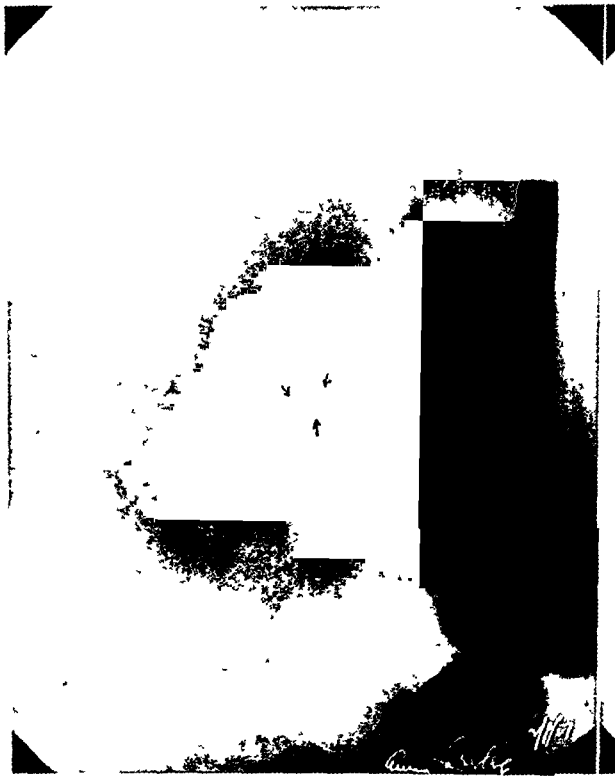


Fig. 4-*A*. Shows a small projecting filling defect on lesser curvature of pyloric antrum



Fig. 4-*B*. Twenty-one months later, showing an irregular cardia, the straight line effect of the lesser curvature, and a small annular filling defect of pylorus.

gastric disease, the pyloric region of the stomach being the most common site of this condition; the greatest care must be exercised in its interpretation. Although this may be the only sign of a lesion present, especially noted in ulceration, the roentgenologist must first determine whether this spasm is produced by a cicatricial filling defect due to an organic lesion or whether it is reflex.

Spasm occurring on the greater curvature as the result of ulceration, known as an incisura and caused by the irritation of the circular muscular fibers, giving the roentgen appearance of an hour-glass stomach, is an example of one of the many instances in which this secondary finding may be of importance in the diagnosis. This sign, however, frequently occurs, on the other hand, without the presence of a filling defect. In a series of sixty-seven cases of gastric ulcer, under observation in our clinic, the presence of an incisura was revealed without a demonstrable filling defect in eleven instances. In one, however, the patient was examined on three separate occasions and no defect was observed, but an incisura was constantly noted. At operation a gastric ulcer was revealed, a finding which was also confirmed by autopsy. In several instances, following numerous examinations, filling defects were finally observed several years after a diagnosis of gastric ulcer had been made from the presence of an incisura alone. The filling defect, when present, usually occurs opposite the incisura. At times, instead of noting a defect, the straight line appearance as described above is observed.

In gastric disease, the earliest pathological changes occur in the mucous membrane at the stage when roentgen signs are still

absent, excepting for spasm, although in some instances peristalsis may be inhibited as a result of irritation. The next stage, however, reveals induration and thickening of the tissues involving the muscular layer, and, as a result of these changes, interference with the normal peristalsis may be observed in the roentgen study. A later stage shows tumor or ulcer formation which is noted by the presence of a defect.

Every gastro-intestinal examination requires a thorough fluoroscopic study, the patient being examined in the antero-posterior, lateral, and oblique positions. A series of films are made in these positions, not only for record, but also to determine the possibility of the presence of a small lesion as well as to avoid overlooking the stereotyped, fixed, or straight line appearance of the stomach, which may occur as the result of the fluoroscopic method. It must be recognized that the fluoroscopic examination cannot always be relied upon in the early diagnosis of small or early lesions of the stomach.

The presence of spasm, revealed as an incisura, the straight line effect and fixed or stereotyped appearance of the stomach suggesting a gastric lesion will often present the additional data required in connection with the clinical manifestations and laboratory findings, which will in most instances assist in arriving at an early and correct diagnosis.

It is interesting to note that the routine test meal showed an achylia in all of our cases in which the roentgen study revealed the stereotyped stomach and in which a diagnosis of carcinoma had been made.



Fig 4-*C*. Same case as shown in Figures 4-*A* and 4-*B*, also illustrating the irregularity of the esophagus at the cardiac end, and also showing the constancy of the straight line effect of the lesser curvature.

CASE REPORTS

The following case reports illustrate briefly the value of the roentgen findings.

Mrs. G. R., aged 61, ascribes her present disturbance to an accident in January, 1928, when she fractured three ribs. In June of that year she began to complain of nausea, regurgitation, and dull pressure in the epigastrium. There was an absence of pain, and the discomfort bore no relation to food. In May she became jaundiced for a period of four weeks and on July 3rd sought medical attention. An X-ray examination at this time revealed a stereotyped, fixed appearance of the gastric outline which appeared constant on all the films. The fluoroscopic examination was negative. No demonstrable filling defect could be detected. The findings suggested a gastric lesion. The gastric contents presented an absence of free HCl; total acidity of 12; blood positive. She was admitted to the hospital in September, three months following the first examination, with complaint of difficulty in swallowing, and vomiting. The X-ray examination at this time revealed a narrowing and irregularity of the pyloric half of



Fig. 5-*A*. Shows the straight line effect on the lesser curvature of the pyloric antrum, at the arrows.



Fig. 5-*B*. Same case, eight months later, illustrating an irregular filling defect.

the stomach, suggesting a malignant condition. Fifteen days later, on re-examination, the esophagus presented a definite obstructive lesion at the cardia. The Wassermann test was negative. At operation a large carcinomatous mass was detected at the cardia of the stomach, extending to the pylorus.

Mrs. A. L., aged 58. This patient gave a history of stomach disturbance of many years' standing, associated with pains in the right side. Recently a loss of appetite and black stools were noted in addition to some loss of weight; vomiting did not occur. In February, 1927, an X-ray examination revealed the typical stereotyped or fixed appearance of the stomach, especially noted on the lesser curvature. No demonstrable defect was observed; the pylorus was somewhat narrowed. The changes suggested an old ulcer. In October, 1928, still complaining of her stomach disturbance, she was re-examined and a partial obstruction of the esophagus at the cardia end was observed The cardia of the stomach was irregular and fixed in appearance; the pylorus showed a small annular filling defect; a large 18-hour retention was also detected. The roentgen diagnosis was carcinoma of the cardia of the stomach, involving the cardiac end of the esophagus, and annular carcinoma of the pylorus, with pyloric obstruction. The examination of the gastric contents was interesting, in that in 1918 there had been an absence of free HCl, with total



Fig 6-*A* Shows the straight line appearance of the lesser curvature at the arrows



Fig. 6-*B*. Same case as shown in Figure 6-*A*, illustrating the constancy of the straight line.

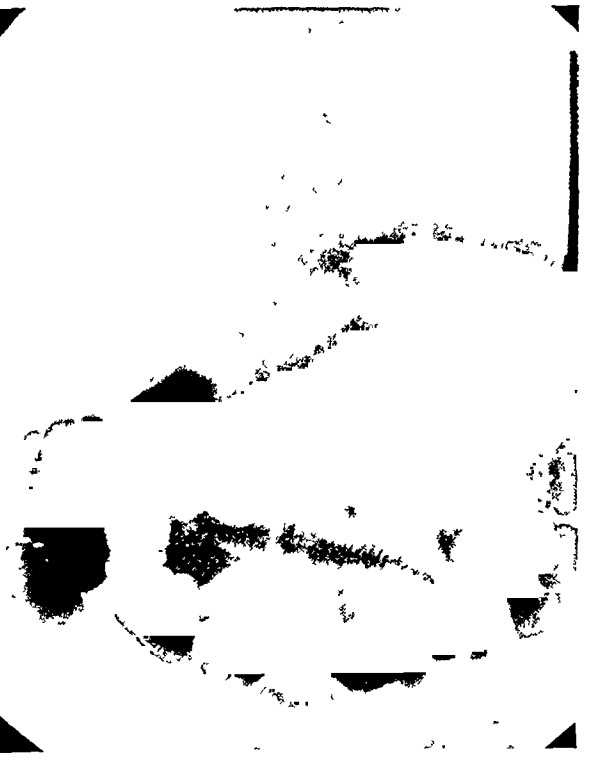


Fig. 6-*C*. Roentgenogram of the stomach of the same case, repeated on the following day showing the constant appearance of the lesser curvature noted in Figures 6-*A* and 6-*B*.

acidity of 12. In May, 1924, there was still an absence of HCl, and total acidity of 11, and on November 17, 1925, the test meal still showed an achylia. On October 3, 1928, the tube could not be passed beyond the cardiac end of the esophagus.

Mrs. M. F., aged 62, had complained of stomach disturbance since 1920, with pains in the left side and back. There were present pains on swallowing, vomiting, poor appetite, sour regurgitation. A fluoroscopic examination at this time revealed a small stomach, with changes suggesting an ulcer in association with right upper quadrant adhesions. No films were made. In September, 1928, or eight years later, she complained of difficulty in swallowing, loss of weight, pains in left chest, substernal distress, and vomiting. The X-ray examination at this time showed a slight retardation of the barium meal at the cardiac end of the esophagus, but no irregularity of the lumen was observed. The stomach was small, well up under the costal margin, emptied rapidly, and presented the typical fixed or stereotyped appearance without the presence of a filling defect. The pylorus and duodenal cap were normal. The findings suggested a gastric lesion. On the fluoroscopic examination these changes were not detected. The diagnosis of a malignant gastric lesion also involving the cardiac end of the esophagus was made. Examination of the gastric contents eight years previously had showed an absence of free HCl. In September, 1928, there was still an achylia present. The Wassermann test was negative. An exploratory operation performed on November 30, 1928, revealed an indurated annular mass at the cardia of the stomach, involving the cardiac end of the esophagus. The stomach was located high

under the costal margin, the mesenteric glands were enlarged and indurated. The diagnosis of carcinoma was confirmed.

Mr. F. L., aged 71, dated his disturbance as having been present since 1923. He complained of pains in the stomach immediately following meals, but retained a good appetite. Neither vomiting nor loss of weight was noted. An appendectomy had been performed in 1918. In March, 1924, an X-ray examination revealed a broad, flattened, straight line appearance of the lesser curvature of the pyloric antrum, and a diagnosis of a gastric lesion, probably an ulcer, was made. In November, or eight months later, he still complained of pains without relation to food. At this time there was still no vomiting or loss of weight. An X-ray examination revealed an irregular filling defect in the same region as the straight line appearance noted in the first examination. These changes suggested carcinoma. The patient later developed a palpable mass. The gastric contents in March showed an absence of free HCl; blood positive. In November there was still an achylia present.

SUMMARY

The early signs of gastric disease as determined by radiological methods are presented, with a description of these findings. The importance of arriving at an early diagnosis without the presence of an organic filling defect is stressed. The fluoroscopic examination in the early stages of gastric disease may not reveal any abnormal changes; however, a series of films usually presents evidence of spasm or abnormal peristalsis. Frequent roentgen examinations are often necessitated, especially when the roentgen diagnosis and the clinical findings do not appear to be in accord.

CONCLUSIONS

1. A stereotyped, fixed, or straight line appearance of the curvatures of the stomach as revealed by roentgen examination occurs as the result of a thickening, induration, and infiltration of the tissues of this organ.

2. Diminished or absent peristalsis or a break in the peristaltic wave is probably the earliest roentgen sign of gastric disease.

3. A small stomach, located high, presenting the fixed and stereotyped appearance, emptying rapidly, even though showing no filling defect, is frequently the result of a carcinoma at the cardia of the stomach.

4. Spasm is frequently the result of a gastric lesion; the incisura is a typical example. It occurred in 16 per cent of the cases of ulceration.

5. The presence of a filling defect is not always necessary in order to establish the roentgen diagnosis of a gastric lesion.

6. The proper interpretation and evaluation of the roentgen signs here described is highly important in the early diagnosis of gastric disease.

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(2) Alvarez, Walter C.: The Mechanics of the Digestive Tract: An Introduction to Gastro-enterology. P. B. Hoeber, Inc., New York, 1928.
(3) Kuttner, L.: Cross-bar Symptom in Diagnosis of Gastric Ulcer (in German). Arch. f. Verdauungskr., April, 1928, XLII, 275.
(4) Bernstein, Arnold: The Study of Normal and Pathological Peristalsis of the Stomach, with the Aid of Polygraphy (in German). Fortschr. a. d. Geb. d. Röntgenstr., April, 1929, XXXIX, 598.

DISCUSSION

Dr. L. T. LeWald (New York): There is one phase of the diagnostic features that I think I can illustrate by a case in which it would not have been necessary to give barium to outline the tumor, as it is shown in contrast to the gas bubble in the stomach. The tumor (Fig. 1) occurred in the cardiac end of the stomach, and tended to obstruct the esophagus. The diagnosis has been confirmed by operation.



Fig. 1. Carcinoma of cardiac end of stomach Note that the tumor can be seen in contrast to the air in the gas bubble, so that the diagnosis might have been made without the use of opaque material.

DR. EDWARD S. BLAINE (Chicago): I wish to add a bit of confirmatory information to certain of the points Dr. Feldman has presented. May I relate an interesting experience that occurred to me rather early in my X-ray work in gastric investigations? Being a first experience this particular event became fixed in my memory, so that I have never forgotten it, but have observed the same X-ray findings frequently since that time.

I had before me a large sized male individual about sixty years of age whose weight of more than two hundred pounds offered considerable difficulty in the way of fluoroscopy. The usual quantity of opaque material was ingested without incident and the shadow of its passage through the esophagus presented nothing unusual. Below the diaphragm the shadow failed to develop the usual gastric configuration. The stomach was of exceedingly small, "steer-horn shape," lying high under the diaphragm, heart, and liver—so high that it was entirely out of reach to palpatory effort. The opaque material poured out into the small bowel without appreciable delay and I was unable to detect any peristalsis. Serial and multiple superimposed exposures made immediately afterwards confirmed the presence of a very small stomach, out of all proportion to so large an individual, and with no appreciable peristaltic waves. I considered this complex as indicating an organ with inflexible walls, and, although the clinical evidence was not regarded by the patient's physician as compatible, I made an interpretation of an extensive scirrhous carcinoma of the stomach. Fortunately for me, this patient was operated on and this diagnosis found to be correct.

Undoubtedly some of those in this audience will recall my routine technic in gastric X-ray examinations, a feature of which is the "polygram," consisting of five or more superimposed exposures of the opaque filled stomach on one 8×10 film. Four of these are made in every examination, in addition to other single exposures of larger sized films. These four 8×10 films give us twenty different exposures, indicating a like number of positions of the gastric waves, one-half of which are made in the morning study and the other half from four to six hours later. On these twenty exposures on four small films we have approached the effect of a fluoroscopic study for a like period, and in this manner have been able to detect local alterations of peristaltic action as well as total absence of movement of the gastric walls. In some cases of early ulcer, as well as early malignancy, we have made a correct deduction on the basis of this technic.

DR. A. R. BLOOM (Detroit, Mich.): I wish to add that I have much appreciated Dr. Feldman's paper, because as a rule when

findings of carcinoma of the stomach are made, it is too late to operate. There is one point brought out by Dr. Feldman which I think should be emphasized, and that is the employment of repeated X-ray examinations. The Mayo Clinic have shown recently that early diagnosis of cancer can be made on repeated examinations. Along this line, I want to recite two cases.

The first case was that of a woman about 38 years of age, who had complained of gastro-intestinal symptoms for about three years. She had been examined in three different clinics, and each time had been diagnosed as negative. When I saw her, a year after her last examination, there was a niche high upon the lesser curvature, about the size of the end of the thumb. I re-examined her in about a month and there was no change in size. She was operated on and the ulcer excised. Grossly there was no evidence of malignancy; on microscopic examination numerous young fibroplastic cells were found. Four months later she died of diffuse metastasis and a mass was found at the site of the lesion.

Another case was of a man about 50 years of age, who had been complaining of heartburn for some ten years. He had had three or four gastric hemorrhages. The week before I saw him, his symptoms had suddenly changed for the worse, and he experienced no relief from soda, as he had done on previous occasions. When I examined him, I noticed a ragged filling defect at the pyloric end of the stomach and made a diagnosis of carcinoma based on this defect, and also on the history of a sudden change of symptoms. Two months later I re-examined him. He was feeling much better and the filling defect was markedly reduced, so that he probably had an inflammatory condition around the pyloric region.

Dr. L. A. Milkman (Scranton, Pa.): Of special interest were Dr. Feldman's remarks about the straightening of the lesser curvature—not only a straightening of the lesser curvature but also an actual shortening. This actual shortening leads one frequently to look out for gastric malignancy.

Dr. S. A. Portis (Chicago): I am very much interested in Dr. Feldman's discussion of his subject. The inflexibility of the lesser curvature is an important roentgenological factor. However, another very important finding where flexibility cannot be determined is the evidence of a small, fine, moth-eaten irregularity of the lesser curvature side. This results, as a rule, from very rapidly growing tumors. They metastasize early, and even though there may not be material enlargement of the original lesion, surgery in these cases offers very little, if any, assistance.

Dr. Feldman (closing): I thank you for the discussion of this paper. In reference to the cascade stomach, we recognize that as an abnormal stomach in most instances, but it does not fall into the type of stomach that I want to impress upon you. We recognize a cascade stomach as one with a defect: the type of stomach which I want to bring out is one without any demonstrable filling effect.

With regard to symptoms, of course the gastro-intestinal patients that I have seen usually have gastro-intestinal symptoms.

Most clinicians disregard the early roentgen signs, because they do not know anything about them. Very few essayists have stressed the early roentgen signs. In fact, when we first spoke of the sign, it was disregarded; and until we had enough cases, especially operative cases, to prove our signs, we were hesitant ourselves and a suggestive impression was given.

In reference to the shortening of the stomach, I mentioned in my paper that the

stomach is usually small, taking into consideration that there is some shortening. There is a peculiar smallness of the stomach which we do not usually see normally.

Mount Vernon Hospital and Radium Institute. Editorial. Brit. Med. Jour., June 28, 1930, No. 3625, p. 1185.

The Mount Vernon Hospital at Northwood has been converted into an institution for the study of malignant disease under research conditions. The medical staff has been reorganized and augmented by workers from other institutions, chosen because of their interest and experience in the radium treatment of cancer.

A working scheme has been drafted for affiliation between the Radium Institute and the Mount Vernon Hospital, under the deanship of Sir Cuthbert Wallace, the combined institution to be called the Mount Vernon Hospital and Radium Institute National Postgraduate School of Radiotherapy. Radium will be furnished by the National Radium Commission, which also supplies the Westminster Hospital Radium Annex, where experiments, on behalf of the Commission, are being carried on with a 4-gram "bomb," in order to determine the value of mass irradiation and long-distance radium therapy.

WALLACE D. MACKENZIE, M.D.

On the Pathogenesis of Eventration of the Left Side of the Diaphragm. Pietro Del Buono. Rivista di Radiologia e Fisica Medica, March, 1930, II, 118.

The author discusses various causes of eventration of the diaphragm, and concludes that in a certain limited number of cases it is possible to admit the congenital origin of the lesion. The more probable causes are inflammatory or neoplastic diseases in the thorax or in the abdomen, from which the diaphragm may be injured, sclerosed, or atrophied. The most frequent cause, however, is ulcerative or neoplastic disease of the stomach, which can be demonstrated radiographically and which is responsible for adhesions and indirect pressure on the diaphragm.

E. T. LEDDY, M.D.

QUANTUM ENERGY OF X-RAYS: A NEW METHOD OF MEASURING IT[1]

By A. MUTSCHELLER, PH.D., NEW YORK CITY

IT MAY be regarded as significant that so little is known about the possible existence or non-existence of specific biological effects of certain wave lengths of X-rays. A possible reason why this field remains practically untouched is that the wave theory of X-rays explains only a certain few facts, but fails to account for many important characteristics of X-rays. The modern quantum theory, on the other hand, accounts for many important characteristics of X-rays, notably those of scattering and the conversion of primary radiant energy into other forms of energy. All these processes are the basis for the utilization of X-rays in therapy. The reason why the quantum theory is not applied more extensively is that the methods, known up to the present, of experimentally measuring the various factors in the quantum expression are too difficult and too elaborate for clinical or even for experimental application.

A new method is described in this paper which by a simple and convenient process enables one to determine the energy of radiation quanta. It is to be expected that this method may be instrumental in directing research and clinical workers into the simpler and much more successful ways of thinking in terms of the modern quantum theory, to take the place of the still extensively applied wave idea of X-rays.

THEORETICAL

In terms of the quantum theory a beam of X-rays is to be regarded as consisting of a stream of a definite number of small units of energy known as quanta. These quanta are projected out from the target of the X-ray tube, and, on penetrating substances (such as, for instance, a mass of biological tissue), there is an effect produced that is proportional to the number of the quanta multiplied by the energy carried by each quantum. In this respect these quanta behave as if they had a definite mass, leading us to think of them exactly as we think of a blast of discrete particles of which each particle carries a definite amount of kinetic energy.[2] Then we know that the bombarding effect of such a stream of particles is measured as the product of the number of particles times the energy of each particle.

Now, in connection with X-ray radiation, we know that the quantum energy is a function of the wave length[3] and also that the wave length is fixedly related to the average absorption coefficient of the radiation.[4] Then, this average absorption coefficient is definitely connected with two coefficients that are easily measured as transmission values of intensities through a known substance as an absorption medium.[5] Each of these functions is represented or expressed by an equation and these three equations can be substituted to give one that expresses the energy of the quanta in terms of these two measurable absorption intensities.[6] The resulting equation is somewhat unwieldy for direct computation and for that reason it is most convenient to read the energy of the

[1] Read before the Radiological Society of North America at the Fifteenth Annual Meeting, at Toronto, Dec. 2–5, 1929

[2] This is the idea of *inertia of energy*, which is one of the principles of Einstein's special relativity, according to which "every quantity of energy of any kind whatever has associated with it a certain amount of mass." See Compton, Appendix I.

[3] Sommerfeld, Arnold J. W., Atombau und Spektrallinien, 3rd Ed., Chapter 4.

[4] Richtmyer, F. K., Physical Rev., July, 1921, XVIII, 13.

[5] The well known experimental absorption equation $\log(I_o - I_x) = m x$.

[6] All mathematical references and equations are omitted from this paper. These will be published in a physical journal.

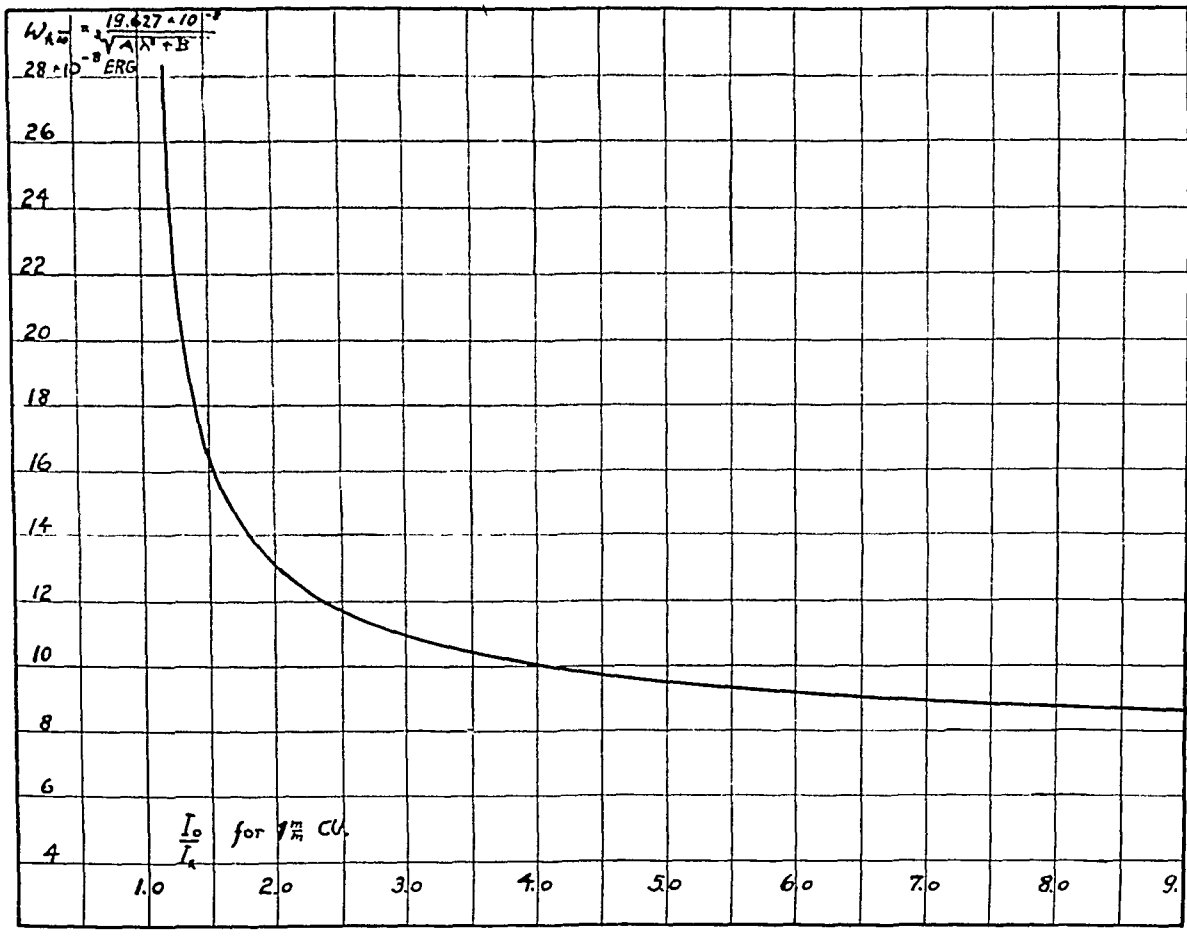


Fig. 1. Curve from which the quantum energy in ergs is read in terms of the ratio of radiation intensities transmitted through 1 mm. of copper.

quanta as ergs from the curve given in Figure 1.

EXPERIMENTAL

At the outset of the experimental work there are three hypotheses either for verification or disproval. These are:

(1) That the dosimeter or iontoquantimeter employed for measuring the radiation intensity actually measures the total energy of the radiation;

(2) That it measures the radiation energy independent of the wave length, and

(3) That the method hereinbefore outlined accurately measures the energy of the quanta, and that this energy as measured by this method is directly proportional to the biological effect of the radiation.

For the experimental testing of these propositions the radiation from a well evacuated high voltage deep therapy tube energized with 4 ma. of constant potential current at voltages measured from the minimum wave length of spectra made with a Seemann spectrograph was employed.[7] A series of absorption curves were made in copper at voltages in steps of 10 kilovolts, from 200 kilovolts downward. From these curves the absorption ratios were read at points on the curve 1 mm. apart. From the curve of Figure 1, then, the quantum energy

[7] Mutscheller, RADIOLOGY, May, 1929, XII, 388.

TABLE I

K.V. d. c. from λ min.	$\frac{I_o}{I_x}$	Mm. Cu passing 10%	r/min. 10 div. = 3.75 r	W = ergs X 10^{-8}*	W from curve ergs X 10^{-8}
129	2.75	1.08	1.60	11.3	11.40
133	2.54	1.22	1.72	11.84	11.75
143	2.26	1.40	1.85	12.42	12.40
152	2.10	1.58	1.90	12.64	12.80
162	1.98	1.81	2.05	13.14	13.25
171	1.83	2.09	2.20	13.97	13.80
181	1.65	2.50	2.40	14.86	14.90
190	1.51	3.00	2.75	16.43	16.60

*W calculated with the equation $W = \frac{9}{4} \times 10^8 \frac{r}{m} + 4.2$, using for r/min. the experimental values in Column 4.

in ergs was read for each of the voltages or wave lengths generated. These are recorded in Column 6 of Table I.

Returning now to the theoretical requirements referred to earlier, we find that at every voltage the total radiation energy as measured with the dosimeter is to be equal to the number of quanta multiplied by the energy of each quantum. If, now, the electrical energy input into the X-ray tube is kept constant, then the number of the quanta making up the radiation would be constant, and thus, by dividing the total ionization energy by the quantum energy, we should obtain a constant numerical value for the number of quanta produced by the fixed electrical discharge through the tube.

To fix the electrical discharge through the tube and thereby to fix as constant the number of quanta of X-rays produced, we proceeded as follows: From the absorption curves (Fig. 2) it was determined at what filter thickness at the various voltages employed, there is transmitted the same percentage of the total radiation, with the proviso that the point representing the filter must lie on the straight line part of the curves. This is necessary in order to satisfy the conditions upon which the validity of the absorption equation used in the derivation of the energy equation is based. The transmission value of 10 per cent was found to be practical, and total intensity measurements in r-units (which are electrostatic units) were made with several dosimeters at filter thicknesses that transmitted exactly 10 per cent of the radiation. The values obtained with one dosimeter actually independent of wave lengths and, of course, obtained by intrapolation from measurements through various available filter thicknesses, are recorded in Column 3 of Table I.

It remains now to test the validity of the three hypotheses with these experimental data. For this purpose there are two ways open. First, by plotting the total radiation intensities measured against the quantum energy, as is done in Figure 3. The points are located along a straight line, indicating that there is a direct linear relation between these factors. Then, the straight line is represented by an equation of the general form of that given by Einstein[8] to represent the ejection of electrons under the impact of a radiation, wherein the energy of the ejected electrons is equal to the energy of the quantum energy minus the energy required to pull these electrons out of the atoms from which they are to be freed. The physical conditions are, therefore, identical with those demanded by the theory.

But still further, we can calculate with the equation of the straight line plot, the values of the quantum energy at each voltage and enter these values calculated from the experimental ionization intensities on the

[8]For an interesting discussion of this equation, see Richtmyer, Introduction to Modern Physics, 1928, pp. 163-65.

curve used to read off the quantum energy, and we find, in Figure 4, that the measured values agree, within experimental errors, with the theoretical requirements.

In the second place, we can, as above outlined, calculate the value for the number of quanta produced by 10 per cent of the radiation corresponding to 4 ma. at a distance of 55 cm. from the target, and we find, as shown in Table II, that the value for the number of quanta is the same at all voltages. Both these tests, therefore, indicate that each one of the propositions made must be answered in the affirmative.[9]

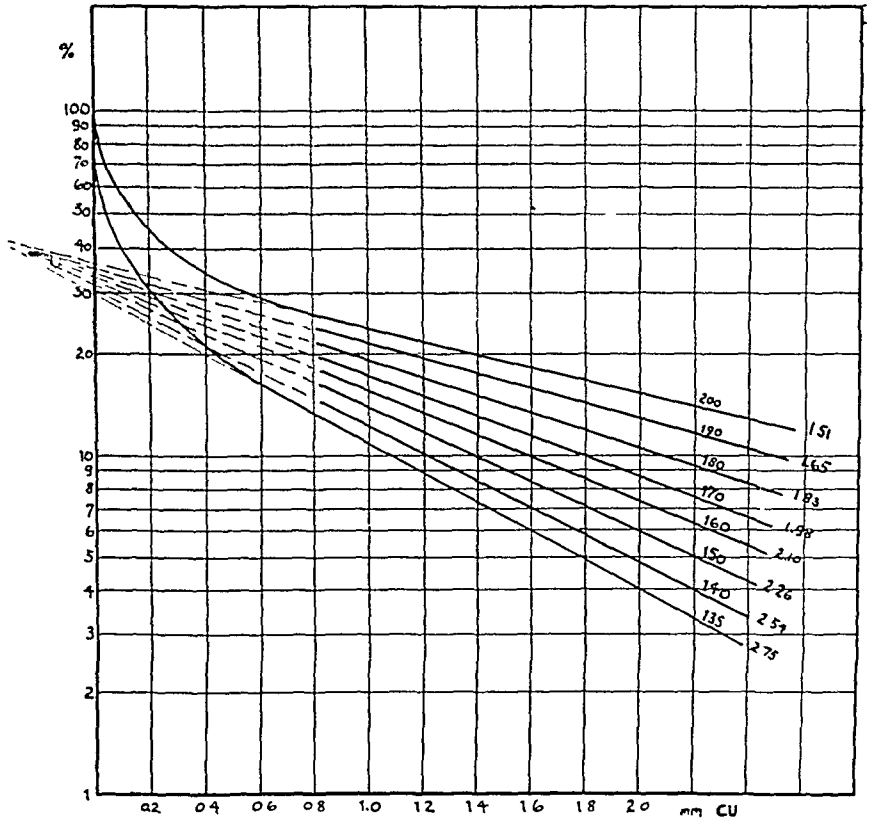


Fig. 2. Absorption curves in copper of various voltages constant potential current.

METHOD OF MEASURING QUANTUM ENERGY

This is the method as it should be carried out in the practical therapy laboratory for the purpose of defining or of measuring the quality of the radiation employed. It may be carried out in either of two ways, of which the second is the preferred one.

The radiation is filtered with a forefilter sufficient to produce a constant absorption coefficient. For this purpose usually a filter of from ½ to ¾ mm. of copper is required: in order to be on the safe side, 1 mm. is better. The intensity of the radiation is measured and then exactly 1 mm. of copper is added and the intensity is measured again. Either the smaller discharge time is divided

[9] Regarding the relation of total energy and biological action of the rays see R. Glocker, Strahlentherapie, 1929, XXXIII, 199; Festschr. d. Technisch. Hochschule zu Stuttgart, 1929, p. 109.

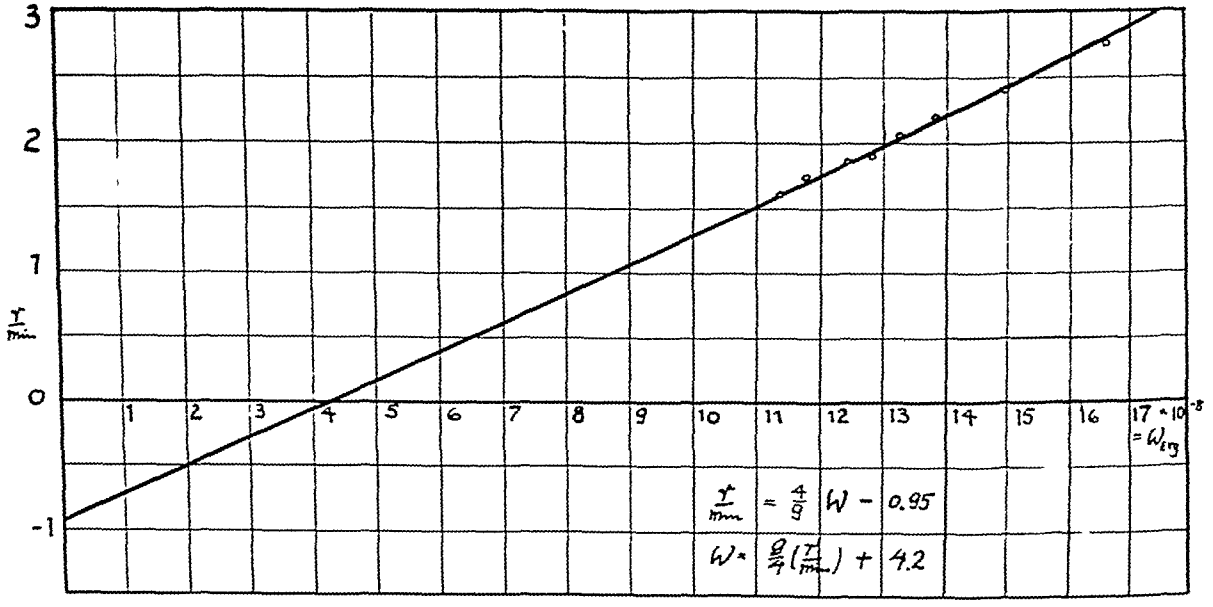


Fig. 3. Plot of the total energy of the radiation measured with a dosimeter and the quantum energy.

TABLE II

Since r/min. $= \frac{4}{9}$ W — .95, a dose of 1 r is produced when the number of quanta per c.c. of air is

$$n = \frac{r/min + 95}{.444\,W}$$

K.V. d. c. from λ min.	r/min. meas.	W ergs X 10^{-8}	n
129	1.6	11.4	.505 × 10^8
133	1.72	11.75	.513 × 10^8
143	1.85	12.40	.510 × 10^8
152	1.90	12.80	.502 × 10^8
162	2.05	13.25	.510 × 10^8
171	2.20	13.80	.514 × 10^8
181	2.40	14.90	.506 × 10^8
190	2.75	16.60	.502 × 10^8
			4.062 ÷ 8 = .508 × 10^8 for the number of quanta

into the larger or the smaller intensity is divided into the larger, and the quotient is the value I_o/I_x. In the curve of Figure 1, directly above this quotient on the base line is found the quantum energy of the radiation in ergs.[10]

The second method consists in making a complete absorption curve in copper and plotting it on semi-logarithmic paper. The data to be plotted are calculated from the discharge times measured by dividing the discharge time measured with the entire filter into the discharge time with 1 mm. less copper as a filter, multiplied by 100. This gives the percentage of the radiation transmitted through 1 mm. of copper for which the curve is computed. It is usually most convenient to employ as filters 0.2 mm. of copper and to take ten readings, to a total filter thickness of 2 millimeters. It is absolutely necessary to test the measuring chamber for leakage and for non-exposure of the electrode, and the best test for that purpose is that the absorption curve from points representing more than ½ or ¾ mm. of copper must be a straight line. An absorption curve offers the assurance over the "two point" method, that no errors in measurements are present and that small experimental errors are evenly distributed on both sides over the entire curve. Also, an absorption curve indicates the correct filter thickness[11] to use, and in a general way lends

[10] A condition is that the electrodes or the walls of the ionization chamber shall not be exposed to X-rays. Either a chamber described in RADIOLOGY, May, 1924, II, 330, or one shown in Figure 5 is to be employed

[11] Mutscheller, RADIOLOGY, May, 1924, II, 330.

itself to very useful interpretations. Of course, readings of intensities may be taken along any part of this curve, so long as the wave lengths, then the assumption is proven. Many instruments in use do not satisfy this condition, and, therefore, it must be said

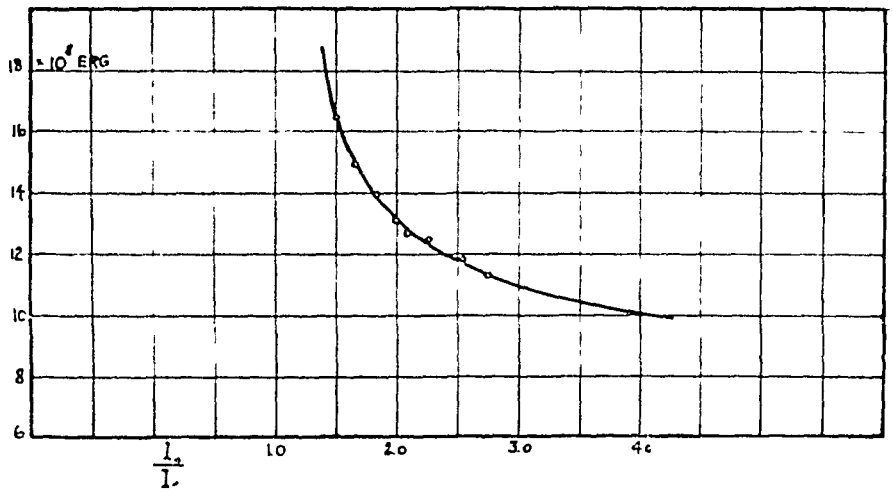


Fig. 4. The experimental values are plotted over the theoretical curve. They show satisfactory agreement between experiment and theory.

distance between the points taken represents 1 mm. of copper, and then the quantum energy is read from Curve 1.

DISCUSSION

We can now look into the matter as to what can be done with these results.

In the first place, we are now using various forms of ionization chambers for measuring radiation intensities in terms of r-units, which are assumed to measure the radiation energy degenerated in 1 c.c. of air under standard conditions. It is also assumed that this is true for all wave lengths within certain limits. Now, inasmuch as such an instrument measures total energy, *i.e.*, the product of quantum energy times the number of quanta, there is nothing to indicate that the assumption is proven correct. But now we can measure the average energy of the individual quanta and if the total ionization current divided by the quantum energy gives the constant value $0\,508 \times 10^8$ for the number of quanta for all that they do not measure independent of the wave length.

Furthermore, the definition of the r-unit has long been a *casus belli*. But on the basis of these quantum developments it is an easy matter to define the r-unit in terms of the number of quanta which, within a certain definite solid angle from the tube, are required to produce an ionization current of 1 E.S.U. There is an almost unlimited field for expansion and simplification now possible, and there are good prospects that the entire dosage problem will be very considerably simplified. We may look with anticipation in the direction of important disclosures in research on the biological effects of various wave lengths or quanta energies. We have to think only of the antirachitic wave length band and the so-called Gurwitsch or mitogenetic rays to feel that there is no reason to consider the existence of more such selective effects at specific wave lengths as impossible.

This work will, therefore, be continued in our laboratories as intensively as is pos-

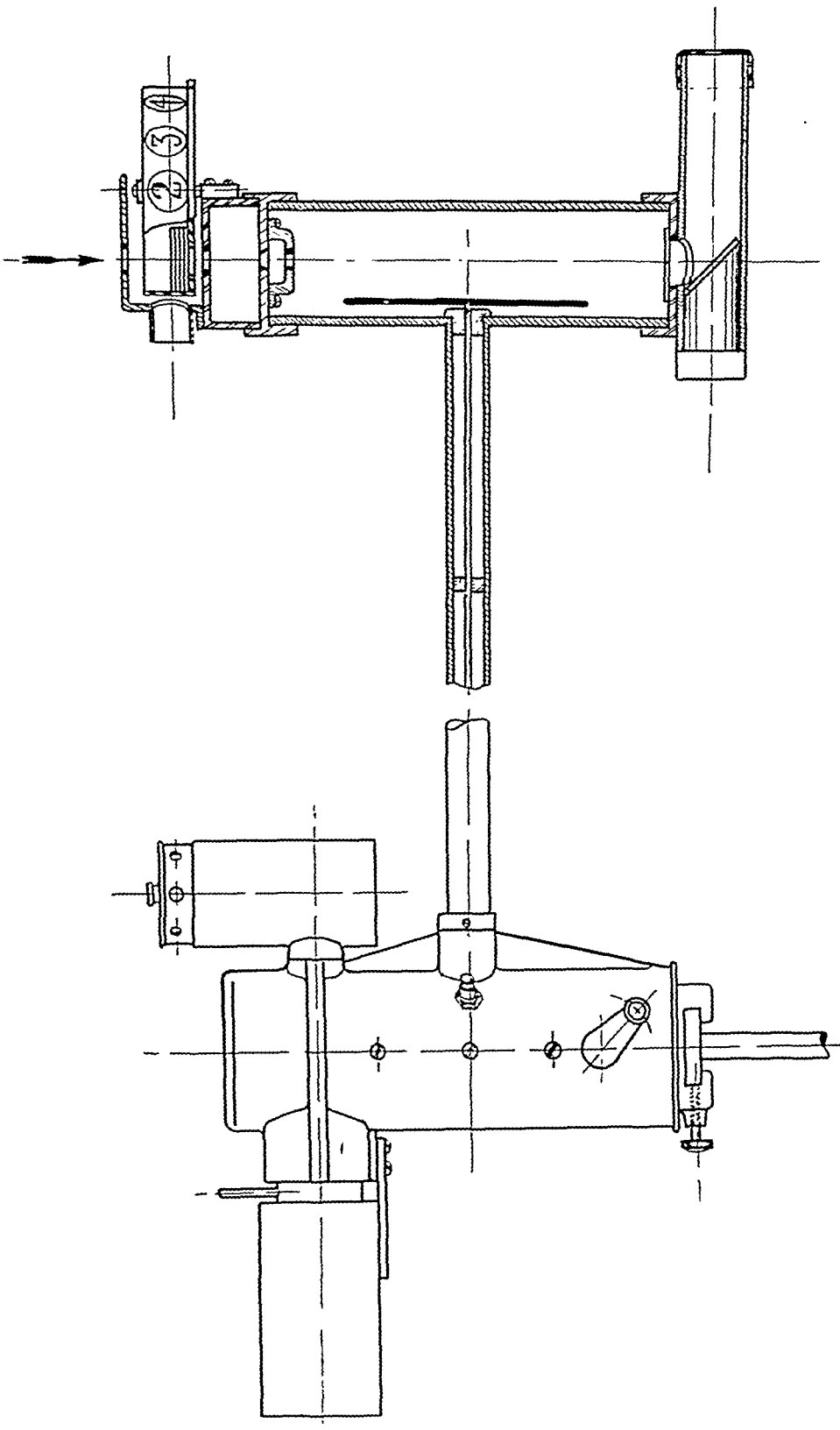


Fig. 5. An ionization instrument found practical for making of absorption curves in copper. The headpiece contains a rotable drum with various copper filters. Note the treble slit arrangement. Below is a reflecting mirror to direct the through path for the rays from the target of the tube.

sible, but I invite the co-operation of every one who is inclined and disposed to participate in this work.

SUMMARY

In this rather early report is shown—

1. A new method of measuring experimentally the quantum energy in ergs of X-ray radiations produced at various voltages.

2. A method of testing dosimeters, *i.e.*, ionization chambers used for intensity measurement, for their dependence or non-dependence on wave lengths.

3. It is pointed out how the clinical aspect of radiation therapy can be simplified by the application of the quantum principle, and that in all probability the clinical effects of X-ray radiation run parallel not with the total ionization effect, the wave lengths, or the absorption coefficients, but with the quantum energy and the total number of the quanta.

4. In view of the facts outlined, it is suggested that clinical radiation data and especially quality measurements be made and recorded in terms of quanta energy or ergs.

DISCUSSION

DR. FRANCIS CARTER WOOD (New York): The problem of trying to discover whether the ionization chamber of the open type, which I believe was originally devised by Perrin and developed by Duane, measures energy or not is one which has occupied the workers in many laboratories for some time. It seems to me that it is the last important problem of radiation measurement left to be solved. Of course, all other ionization chambers have to be checked against the open one to see whether their readings are correct. Of late one of the commercial machines has been tested against flies' eggs, which do not show any wave length effect, and found to correspond within about 2 per cent to the biological test. Practically, I think the biological test is the important thing, for the radiologist does not care anything about the purely physical side. The important thing is that we are applying radiation to another biological object, the human body. It is interesting to see how many people have guessed at this question of relationship between the ionization and energy. Both sides have proved to everybody's satisfaction that the ionization does not read energy and that it does read energy! So far as I am concerned, I have always held to the view stated to me fifteen years ago by Professor William Duane, that the only possible relation of the action of X-rays would be the energy one, that is, the effect would be directly proportioned to the energy absorbed. For this reason I have always assumed, though knowing it not proved, that the open ionization chamber did measure energy. In our biological experiments the column of air has about the same absorption as the flies' eggs, and therefore we are working with exactly the same portion of the absorption curve.

As to this ingenious paper, the question is if the short wave lengths give off a larger number of quanta, why do not those quanta do more damage to the cells? And thus we are thrown back on the same old thing, that they are less absorbed in the tissues, and back we go to the absorption of the open ionization chamber as the sole measure of the amount of effective energy which hits minute biological elements. What that effective energy does when it hits the human body, in which very complicated scattering takes place, is quite another problem, and I have confined myself solely to discussing the phenomena which occur in these small eggs or very small tumor particles where all scattering is eliminated; in other words, simplifying the problem as much as pos-

sible. The more complicated problem belongs to the clinician.

DR. LAURISTON S. TAYLOR (Washington, D. C.): Dr. Mutscheller's work is clearly along the most advanced lines, and while I am not completely clear in my own mind at this time about the full details of it, inasmuch as I have not seen his completely worked out publication, it is to be hoped that it will lead us somewhere correctly, and in terms of energy. Up to the present there have been only two or three determinations made of the absolute energy of an X-ray beam. These determinations involve some of the most difficult tasks that have been confronted, because of the extremely weak intensity being dealt with. I believe that for a very powerful water-cooled tube operating at one hundred milliamperes and about sixty kilovolts the energy is one one-hundredth of an erg per minute, which is almost less than nothing at all. The method used to investigate this involves a medium which can be exposed to the X-ray beam, and absorbing the total amount of energy, it then becomes possible to measure the resulting very slight increase in the temperature of this body. Dr. Terrill has tried this at the Crocker Institute. Crowther has tried it in England and Kulenkampff and Rump have tried it in Germany, and unfortunately all of them disagree, so that so far as an absolute measurement of X-ray energy is concerned, we are still in doubt. It is to be hoped that this work of Dr. Mutscheller's, while not an absolute method of measuring the energy, will at least give us a way of arriving at the energy by some other route.

DR. G. FAILLA (New York): Since I have not read Dr. Mutscheller's paper I find it impossible to discuss certain technical points in it from the abridged presentation I have heard. Of course, it would be important to measure the actual energy in an X-ray beam. Many attempts have been made in the past, but they have not been very successful on account of the minute quantities of energy involved. Dr. Mutscheller apparently has attacked the problem in an indirect way and this may lead to some interesting results.

In this connection, it seems to me there is an important point which should always be borne in mind. In considering the effects of radiation it is not the actual amount of energy falling upon the irradiated substance which is important, but, rather, the fraction of this amount which is effective in producing the observed change. For instance, when hard X-rays are used, most of the energy of the beam passes through the superficial layers of the material and can have no effect on it. Only the small amount which is absorbed is responsible directly or indirectly for the changes produced.

Applying this mode of reasoning to ionization measurements, it will be seen that the ionization chamber measures only the fraction of the radiation passing through it which is absorbed by the air in the chamber or is in some way effective in producing ions (for instance, by liberating high speed electrons from the walls of the chamber). In order to measure the total energy in an X-ray beam by means of an ionization chamber, the latter would have to be so large that the scheme becomes impractical.

But granting that by making certain assumptions one can calculate the energy in an X-ray beam, it does not seem to me that this information will help us materially in the correlation of radiation dose and biological effect produced. As already stated it is not the total energy of the beam that counts, but the part that is biologically effective. This varies with the wave length of the radiation. As a matter of fact, it is reasonable to expect a simpler relation between radiation and biological effect if the radiation is measured by a suitable ionization chamber, than by determining the total energy of the beam. In other words, the

ionizing effectiveness of a beam of rays is apt to be a good index of its biological effectiveness, irrespective of the wave length. However, this question cannot be settled *a priori* and has not been settled experimentally.

The best available information on this problem has been supplied by Packard's experiments in Dr. Wood's laboratory. It has been found there that equal amounts of X-rays produce the same effect on *Drosophila* eggs over a wide range of wave lengths. This result is definitely established, but I think we are not justified in assuming that the same result would be obtained with all other biological media. If this were the case then the same relation should also hold for the production of skin erythema with X-rays of different quality. According to some experiments, however, this is not the case.

In attempting to explain the apparent discrepancy, Wood points out that erythema is a very complicated reaction in which many different types of cell take part. Furthermore, scattered radiation, which is practically absent in the *Drosophila* experiments, plays an important part in the erythema experiments. It seems to me that this explanation is not wholly satisfactory. If we assume that the effect of radiation on all living cells is independent of the wave length, then skin erythema should also be independent of wave length. The pressure of scattered radiation cannot influence the result, *provided it is also included in the ionization measurement,* because it differs from the primary radiation only in quality. However, skin erythema involves many complications and I agree with Dr. Wood—although on different grounds—that such experiments are not in the same class as the *Drosophila* experiments.

DR. FRANCIS CARTER WOOD (New York): Perhaps Dr. Failla has left a false impression of my statement in which those who are here might be interested. I meant to say that the process which occurs in a complex body made up of tissues of very different sensitivities, of extraordinary anatomical complexity, renders the discovery of the relationship between wave lengths and effect a very much more difficult matter than when you simplify it by using small groups of cells, such as tumor particles or fly eggs, and that that problem of the production of an erythema is a problem of clinical investigation because that erythema may very well be due to different quantities of energy with different wave lengths, because the erythema is a clinical reaction and not a pure biological phenomenon. Let us assume that the capillaries of the vessels are less damaged by short wave lengths than by long; each capillary cell may be damaged independently of the wave length, but the total reaction produced may be different. I do not think it is, and I am not prepared to make any dogmatic deductions from small groups of cells to large masses of cells which react in different ways. That is the condition of the problem.

DR. MUTSCHELLER (closing): I wish to refer to two points which I think have been brought out in the discussion. One is that this work has just been begun and that very much more work is to be done in order to be able to answer such questions as: "What is the definite relation between the total energy of the X-ray beam and the factors which can be measured now, namely, the energy of the quanta?" The second point, however, is that I think the effect upon the entire therapy problem which can be gained from a consideration of the radiation phenomena from the quantum point of view, will probably be to clarify many obscure propositions which, up to the present time, have not been readily visualized. I think Dr. Wood has referred to a number of such factors; and of those, we could in particular pick out one. What is really the difference in bio-

logical effect between what we call a low penetrating radiation, consisting of quanta that have a small amount of energy, and a highly penetrating radiation which consists of quanta possessing a large amount of energy? What is the difference between the two? I think Professor Glocker, in speculating in an entirely different manner, has arrived at a picture which is somewhat as follows: if we think of a cell as consisting of atoms, and atoms naturally as made up of electrons, we can imagine a radiation quantum possessing a large amount of energy as jumping from atom to atom, being stripped by each of a certain amount of energy which then remains in that atom, until it comes down to that stage where the quantum will finally be stopped. If such a quantum has a large amount of energy, it will jump through a very large number of atoms, and in that way leave a large amount of energy in that particular mass of cells or atoms. If, now, another quantum comes along—possibly across the path of the first one or following along the same track—it will also leave its energy with the various atoms, and finally there may have enough energy accumulated in the various atoms to cause the expulsion of an electron and therefore to cause ionization. The result would be a chemical effect which we actually do recognize, such as the coagulation of albumin or something of that sort. In other words, the total amount of energy of a highly penetrating quantum is distributed over as many atoms as are necessary to absorb all of its energy. In that way we can imagine that a highly penetrating radiation will then exert a very large biological effect, but only if there is a large mass of tissues. If we now think only of a few cells, such as a few *Drosophila* eggs in one plane, everything becomes simple and we immediately draw the conclusion that the biological effect on that layer of *Drosophila* eggs will be independent of the quantum energy or of the wave length.

Now I would just like to make this point, that I think the wave idea, to which we have clung up to the present, has explained many things, but has actually failed to explain a lot of other equally or more important things such as the scattering of X-rays and the specific effect of radiations of different wave lengths. But I think that if we now change over and think, for a little while, at least, in terms of the quantum idea, we may perhaps explain a lot of things and clarify and develop clearer and simpler aspects which will help very much more in the understanding of the biological relation of physical and biological factors in radiation therapy.

PARAVERTEBRAL ABSCESS

AN EARLY ROENTGEN SIGN OF TUBERCULOUS SPONDYLITIS[1]

By LEO G. RIGLER, M.D., WALTER H. UDE, M.D., and M. B. HANSON, M.D.
University of Minnesota, MINNEAPOLIS, MINNESOTA

THE percentage of cases of spinal tuberculosis which are accompanied by a paravertebral abscess has been variously estimated at from 20 to 100 per cent. Careful postmortem studies indicate the presence of abscess in about 80 per cent of the cases of thoracic spine tuberculosis, with considerably less frequency in the other portions of the spine. The clinical recognition of abscess is in many cases difficult, and Whitman (1) quotes various studies to indicate its detection by clinical means in approximately 20 per cent of all cases. Steindler (2) by both clinical and roentgen methods found abscess in 30 per cent of all his cases of spinal tuberculosis and in 45 per cent of the thoracic spine cases. The best premortem figures are those of Sgalitzer (3), who was able to detect abscesses roentgenographically in 66 per cent of his cases with thoracic spine involvement.

The importance of the roentgen diagnosis of paravertebral abscess is well recognized and is emphasized in all standard books on orthopedic surgery and roentgen diagnosis. It is important in establishing definitely a diagnosis of spinal tuberculosis, in determining the limits of the disease, and in evaluating the progress and prognosis of the particular case. The presence of abscess, however, is usually considered to be confirmatory of the diagnosis previously established by the clinical findings and the roentgenographic evidence of involvement of the vertebral bodies and intervertebral discs. Because the characteristic shadow of an abscess about the spine is almost pathognomonic

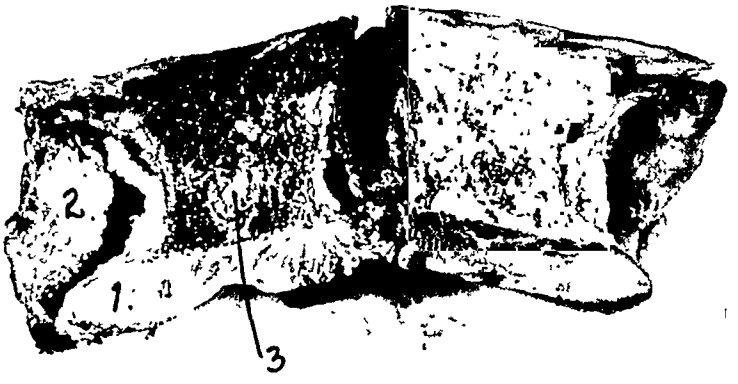


Fig. 1. Photograph of sagittal section of a vertebral body from a case of tuberculous spondylitis. Note the central caseation (3), the deep erosion of the centers of the anterior surface of the bodies (2), the comparatively moderate narrowing of the intervertebral disc (1), and the absence of compression of the body of the vertebra.

[1]From the Departments of Roentgenology of the University of Minnesota, the University Hospital, the Minneapolis General Hospital, and the Lymanhurst School for Tuberculous Children, Minneapolis, Minn.

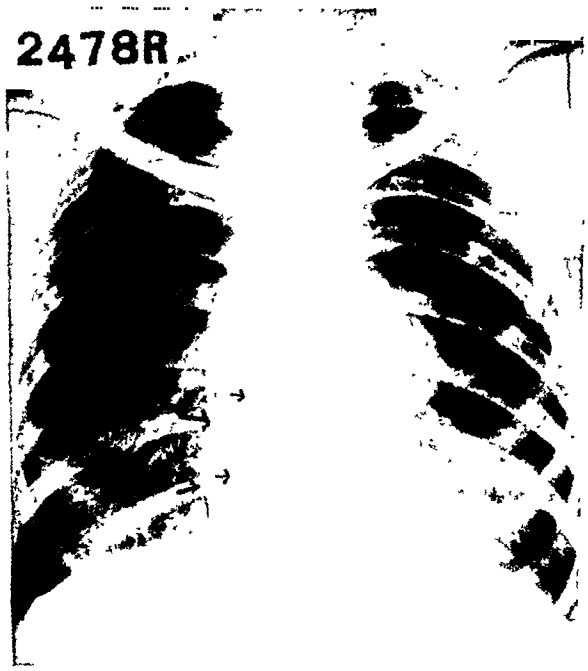


Fig. 2. Postero-anterior roentgenogram of the chest of Case 1. Note the large shadow (indicated by the outer arrows) of the abscess superimposed upon the heart and large vessels. The abscess is exaggerated in size because of its distance from the film. The inner arrows on the right indicate the cardiac outline.

of tuberculosis it serves to clinch the diagnosis when the character of the vertebral change may leave some doubt. It is true that osteomyelitis may give a somewhat similar appearance but this is the only exception.

That the roentgen diagnosis of paravertebral abscess may be the first positive evidence of spinal tuberculosis and may clearly precede any visible changes in the spine itself is not so generally recognized. Such recent works on the spine as those by Steindler (2) and George and Leonard (4) make no mention of this fact and its importance is generally overlooked. Sgalitzer (3), in 1919, was probably the first to call attention to this interesting phenomenon, and in a recent article (5) he reports a number of cases of this type. Hass (6) also noted that roentgenographic signs of paravertebral abscess might precede similar signs in the spine itself. Sever (7), in emphasizing the importance of the visualization of an abscess in the diagnosis of spinal tuberculosis, noted that "perivertebral thickening" might precede the visible bone changes. Erdheim (8) has repeatedly observed at autopsy the presence of paravertebral abscesses which directed attention to the spine. The latter in these cases might be grossly normal with no gibbus, no collapse or obvious destruction of the vertebral body, and no narrowing of the intervertebral disc. On section, however, very small central caseous areas of tuberculosis were found, which no doubt served as foci for the abscess. These central foci are frequently multiple, but when single and very small it is not surprising that they may be quite invisible in the roentgenogram.

Willis (9) in a roentgen and anatomical study upon the cadaver reported several cases in which he found a large thoracic abscess without any changes in the vertebræ which could be seen in the antero-posterior roentgenogram. In the lateral view, however, some erosion of the anterior surfaces of the bodies could be made out, but this was clearly due to pressure from the abscess. In these cases no narrowing of the disc and no angulation was present. Figure 1 is a photograph of a sagittal section of a vertebral body loaned from the Department of Pathology of the University of Minnesota. It illustrates aptly this type of case, as it shows the central area of caseation (3), the erosion of the anterior surface of the spine by the massive paravertebral abscess (2), which was present, the comparative lack of narrowing of the intervertebral disc (1), and the absence of collapse of the body of the vertebra. Ghormley and Bradley (10) have described this "aneurysmal" erosion of the bodies of the vertebræ, which is clearly due to pressure from the abscess.

Sgalitzer (5) believes that those cases in which there is a definite paravertebral abscess without visible changes in the spine may represent a very early stage of tubercu-



Fig. 3-*A*. An antero-posterior roentgenogram of the spine in Case 1. The typical, irregular, bilateral, fusiform-shaped abscess shadow is outlined by the arrows. Note the normal appearing vertebræ.

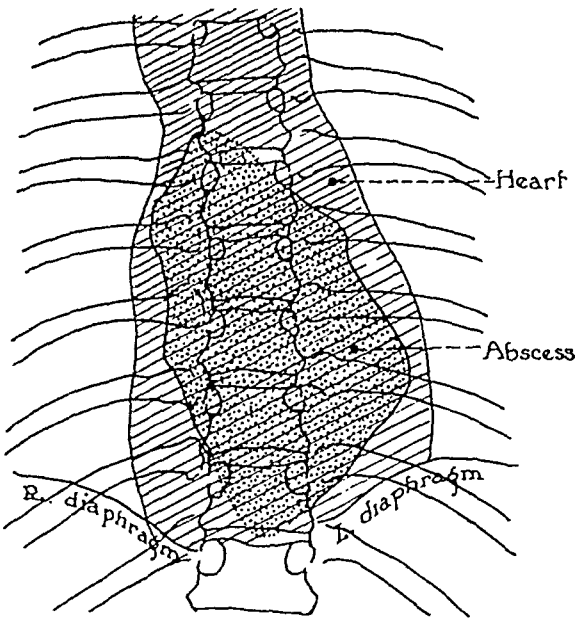


Fig. 3-*B*. Drawing from a tracing of Figure 3-*A*.

lous spondylitis. If followed for a period of time, definite bone and cartilaginous changes will appear. Another group may represent a very benign form of tuberculous spondylitis which fails to break down sufficiently to invade the intervertebral disc or to produce the typical collapse of the vertebral body.

The early recognition and differentiation of paravertebral abscess from other conditions is obviously a matter of some importance. As has been stated, they are most common in the thoracic region. They may also occur in the cervical region, while in the lumbar region psoas abscess is more frequent. The roentgenographic characteristics of the latter have been fully described by Kloiber (11). Sgalitzer (5), Schmid (12), Pitzen (13), Ghormley (14), and Massart and Ducroquet (15) give excellent and detailed descriptions of the appearance of paravertebral abscess. It is sufficient here to note the spindle-shaped form, symmetrical bilateral appearance, and slight irregularity of the margins of the shadow about the spine. These findings are well illustrated in Figures 3-*A* and 3-*B*, which represent the abscess in the antero-posterior view. Very little of the abscess shadow can be seen in the lateral view. The esophagus and trachea may be displaced anteriorly if the abscess is large. Usually it tends to extend down to the diaphragm first and then may attempt to rupture outside the usual boundaries.

It is notable that the shadow of the abscess may be lost in that of the heart, as Dubrow (16) has pointed out, and if postero-anterior films of the chest are made it may give the appearance of a bilateral mediastinal effusion. This is well illustrated in Figure 2 and was also present in our second case. The superimposition of the shadows of the various chambers of the heart, the descending aorta, the other large vessels, the paravertebral muscle shadows, and the reflection of the posterior medias-



Fig. 4. Lateral roentgenogram of the spine in Case 1. Note the very slight erosion of the anterior surfaces of the bodies of the seventh and eighth thoracic vertebræ. There is no destruction in the bodies and no narrowing of the intervertebral disc.

tinal pleura all serve to make the diagnosis difficult. The bilateral character of the paravertebral abscess shadow and its characteristic spindle-shape are the most important differential factors. Osteomyelitic abscess usually gives more pronounced findings in the spine itself and a very different clinical history. Mediastinal pleurisy, enlarged thymus and other mediastinal tumors, aneurysm of the aorta, and abscess from the ribs or sternum must be ruled out. It should again be emphasized that small abscesses are easily overlooked.

We have observed four cases of tuberculous spondylitis, in two of which the paravertebral abscess was the first roentgen sign, preceding visible bone changes. In the other two the findings in the vertebral column itself, although visible, were comparatively minimal, while the abscesses were large and characteristic.

CASE REPORTS

Case 1. White female, aged 32, admitted to the medical service of the Minneapolis General Hospital because of weakness, fatigue, diarrhea, blood in stools, and swelling of the ankles. Has had pulmonary tuberculosis diagnosed four years previous to present admission. Pains in back have been present for nine years. Diarrhea and intermittent temperature have been present for six months, following a pelvic operation.

Physical examination revealed marked emaciation, general anasarca, anemia, and a low blood pressure. There was an area of dullness over the left thorax posteriorly. The abdomen was distended, with fluid in the flanks. There was little or no pain on percussion of the spine.

The urine, blood, and clinical picture indicated a toxic nephrosis or amyloidosis of the kidney.

Roentgen examination of the chest (Fig. 2) revealed some calcified tuberculous nodules in the right apex, but no evidence of recent or active tuberculosis. A large shadow extending beyond the borders of the heart on both sides was also present. Its irregular character and bilateral distribution suggested a paravertebral abscess which had become grossly exaggerated in size because of the usual postero-anterior chest position. Films of the thoracic spine made in the antero-posterior position showed a marked reduction in size of the shadow, which presented the classical picture of paravertebral abscess (Figs. 3-*A* and 3-*B*). No abnormal changes in the vertebræ could be made out. A lateral view (Fig. 4) showed some slight erosion on the anterior surfaces of the bodies of the seventh and eighth thoracic vertebræ but the intervertebral discs

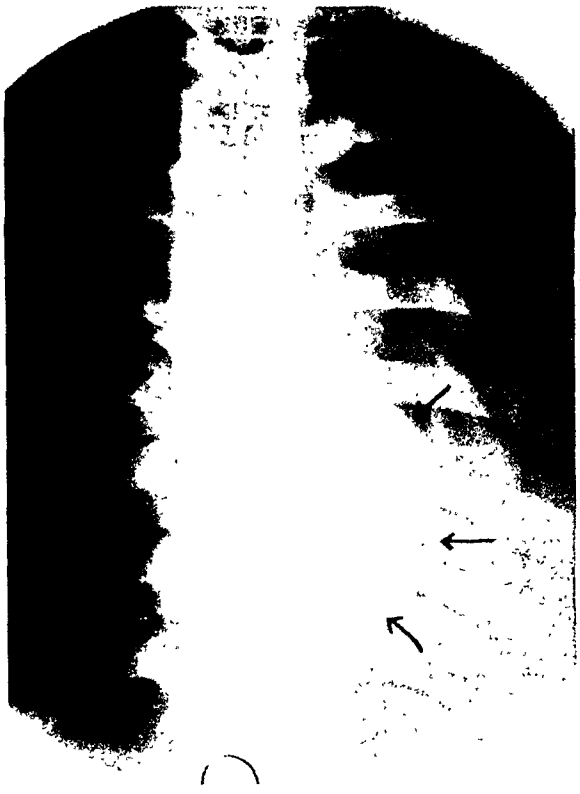


Fig. 5-*A*. Antero-posterior roentgenogram of the spine in Case 2. Note the large, bilateral, somewhat rounded abscess shadow outlined by arrows. The vertebræ appear normal.

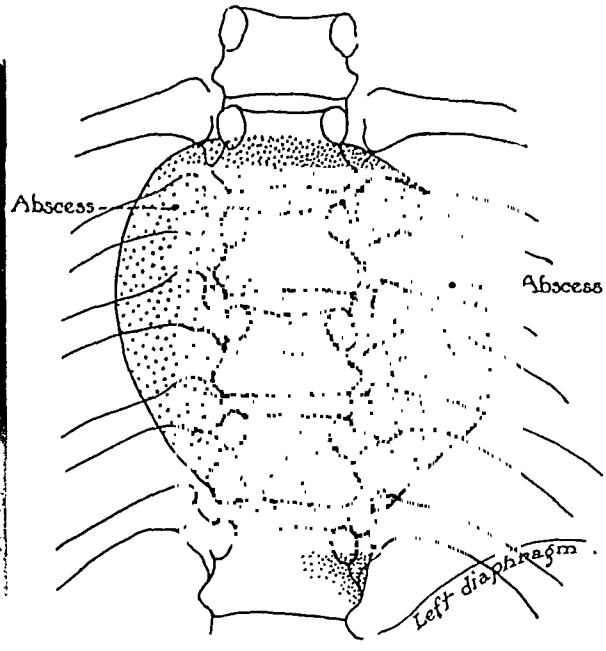


Fig. 5-*B*. Drawing from a tracing of Figure 5-*A*.

were not narrowed and there was no destruction within the bodies of the vertebræ. The slight changes on the anterior surface may be interpreted as due to pressure from the abscess.

Postmortem examination by Dr. C. J. Watson gave the following pertinent findings: (1) Chronic pulmonary tuberculosis, fibroid and calcified right apex; (2) amyloidosis of spleen, kidneys, and liver; (3) tuberculosis of the right kidney and left adrenal; (4) tuberculosis of the ilium; (5) a large "cold" abscess about the seventh and eighth thoracic vertebræ extending well above and below this level and along the ribs. The abscess extended somewhat into the intervertebral joint between the seventh and eighth thoracic vertebræ and eroded their anterior surfaces. It appeared to arise from within the bodies of the seventh and eighth thoracic vertebræ, but the changes in the bodies themselves were minimal.

Case 2. White male, aged 14, was referred to the Out-patient Department of the Lymanhurst School for Tuberculous Children because of malnutrition and as a tuberculosis suspect. Symptoms were negligible but the temperature varied from 99.2° to 100°. Physical examination showed only a scoliosis of the thoracic spine but was otherwise negative. The Von Pirquet and Mantoux skin tests were slightly positive.

A roentgenogram of the chest was made and a shadow in the region of the seventh to the ninth thoracic vertebræ could be made out, superimposed upon the heart shadow and lying within it. The appearance suggested a paravertebral abscess. An antero-posterior roentgenogram of the thoracic spine showed the typical appearance of a paravertebral abscess (Figs. 5-*A* and 5-*B*)



Fig. 6. Lateral roentgenogram of the spine in Case 2. Note the lack of visibility of the abscess and the normal vertebræ of a growing child.

but in the lateral view (Fig. 6) no evidence whatever of tuberculosis of the vertebral bodies or intervertebral discs could be seen. Nevertheless a diagnosis of tuberculous spondylitis was made.

Four months later a re-examination of the thoracic vertebræ was made. This showed slight destruction of the anterior and inferior portions of the sixth vertebral body which was fairly typical of tuberculosis.

Case 3. White male, aged 45, was admitted to the neurological service of the University Hospital complaining of difficulty in walking, loss of sensation in the lower extremities, staggering in the dark, gas distention, and constipation. He had suffered some pain in the back several months before, which had been relieved by "light treatments." The neurological symptoms had appeared during the past few months.

Physical examination revealed some evidences of paraplegia involving the lower extremities, but no other significant findings. The temperature ranged from 99.0° to 100° in the afternoon until he developed a pleural effusion, when it rose to 102.2°.

Roentgen examination of the whole spine revealed a characteristic, irregular, spindle-shaped shadow in the thoracic region extending from the seventh to the ninth vertebræ, typical of paravertebral abscess (Figs. *7-A* and *7-B*). In the lateral view (Fig. 9) the eighth and ninth bodies showed a slight mottling, indicating a destructive process, but there was very little narrowing of the intervertebral disc. The eleventh thoracic vertebra also showed some loss of density. A roentgen diagnosis of tuberculosis of the eighth, ninth, and eleventh thoracic vertebræ, with paravertebral abscess, was made.

Roentgen examination of the chest was negative. Later the patient developed a pleural effusion, which, however, was negative on guinea pig inoculation.

He was transferred to Glen Lake Sanatorium, where the paraplegia has gradually disappeared and he has made slow but satisfactory progress.

Case 4. White female, aged 32, was admitted to the medical service of the Minneapolis General Hospital complaining of pain in the lumbar region and pleurisy pains. These had followed an abortion eight weeks previously. The pain had become worse and was aggravated by bodily movements and deep inspiration.

Physical examination revealed tenderness over both kidney regions, most marked on the right under the costal margin. There were no other essential findings.

Roentgenographic examination of the lower thoracic and lumbar spine showed a small spindle-shaped bilateral shadow, about the bodies of the seventh to the tenth thoracic vertebræ (Fig. 9). This was characteristic of paravertebral abscess. In the lateral view (Fig. 10) there was some evidence of narrowing of the intervertebral

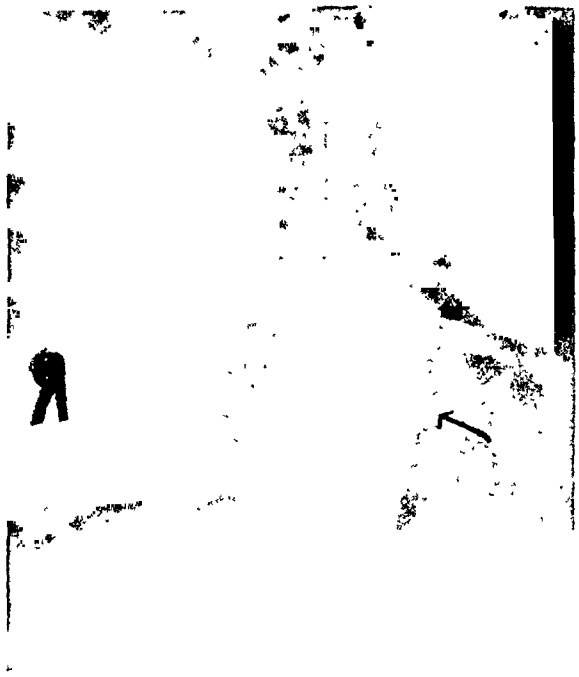


Fig. 7-*A*. Antero-posterior roentgenogram of the spine in Case 3. The large very irregular abscess shadow is seen extending down to the diaphragm on the left. Slight decalcification of the bodies of the ninth and tenth thoracic vertebræ, together with narrowing of their intervertebral disc, is shown.

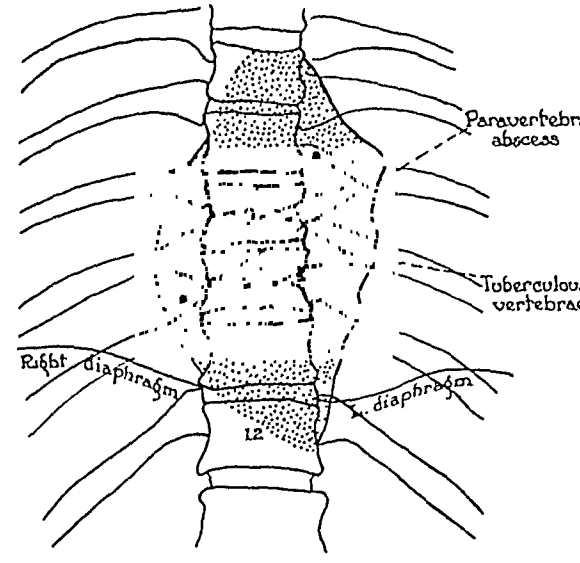


Fig. 7-*B*. Drawing from a tracing of Figure 7-*A*. Note the slight changes present in the ninth and tenth vertebræ and the intervertebral disc.

disc between the ninth and tenth thoracic vertebræ, with slight erosion of the articular surface of the ninth. A roentgen diagnosis of tuberculosis of the ninth and tenth thoracic vertebræ, with paravertebral abscess, was made.

COMMENT

The first two cases illustrate aptly the appearance of a paravertebral abscess in the ordinary postero-anterior chest film and the accidental discovery of this condition which was clinically unsuspected. The lack of roentgenographic findings in the spine is obvious and the large, definite, abscess shadow was the first evidence of tuberculous spondylitis either clinically or roentgenologically. The first case was confirmed by autopsy, while the eventual course in the second indicated clearly the presence of tuberculosis of the vertebræ. In Case 2, especially, the roentgen observation of the abscess made possible a very early diagnosis.

Cases 3 and 4 illustrate the importance of the roentgen demonstration of paravertebral abscess as a diagnostic sign of early tuberculous spondylitis, as the roentgenographic findings in the vertebræ themselves in either case are not entirely characteristic. The multiplicity of involvement in Case 3, for example, led to a clinical diagnosis of possible metastases rather than tuberculosis.

SUMMARY AND CONCLUSIONS

Paravertebral abscess occurs very commonly in tuberculosis of the thoracic vertebræ but is clinically unrecognized in many cases.

Its roentgen diagnosis is important because it is almost pathognomonic of tuberculous spondylitis.

It may be the earliest roentgen sign of



Fig. 8. Lateral roentgenogram of the spine in Case 3. Note the mottled appearance of the ninth and tenth thoracic vertebræ resembling metastases The narrowing of the ninth intervertebral cartilage is slight but definite.

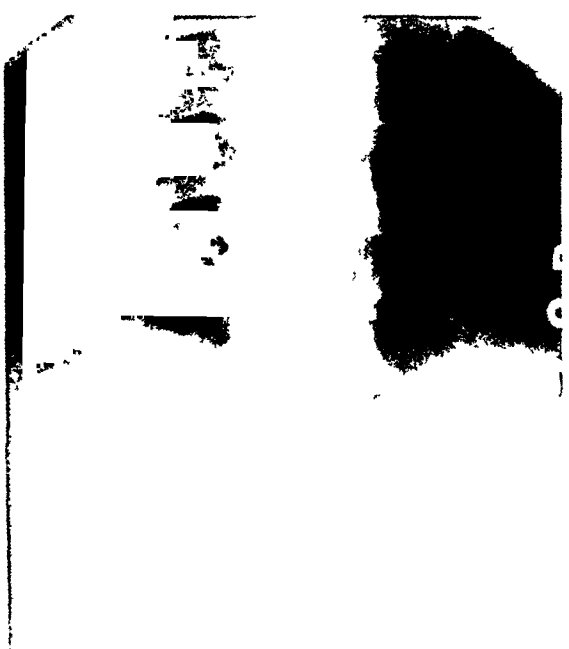


Fig 9 Antero-posterior roentgenogram of the spine in Case 4 Note the small abscess just above the diaphragm and the barely perceptible changes in the bodies of the ninth and tenth thoracic vertebræ



Fig. 10 Lateral roentgenogram of the spine in Case 4. Note the slight narrowing of the ninth intervertebral cartilage and the rarefaction of the posterior portion of the ninth vertebral body

tuberculous spondylitis appearing before there are any visible changes in the bodies of the vertebræ. Two cases of this type are reported.

It may be present in characteristic form while the changes in the vertebral column are still minimal or not entirely diagnostic roentgenographically. Two cases of this type are reported.

Paravertebral abscess may overlap the shadow of the heart in the ordinary chest roentgenogram, simulating a mediastinal process.

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UROGRAPHY BY UROSELECTAN

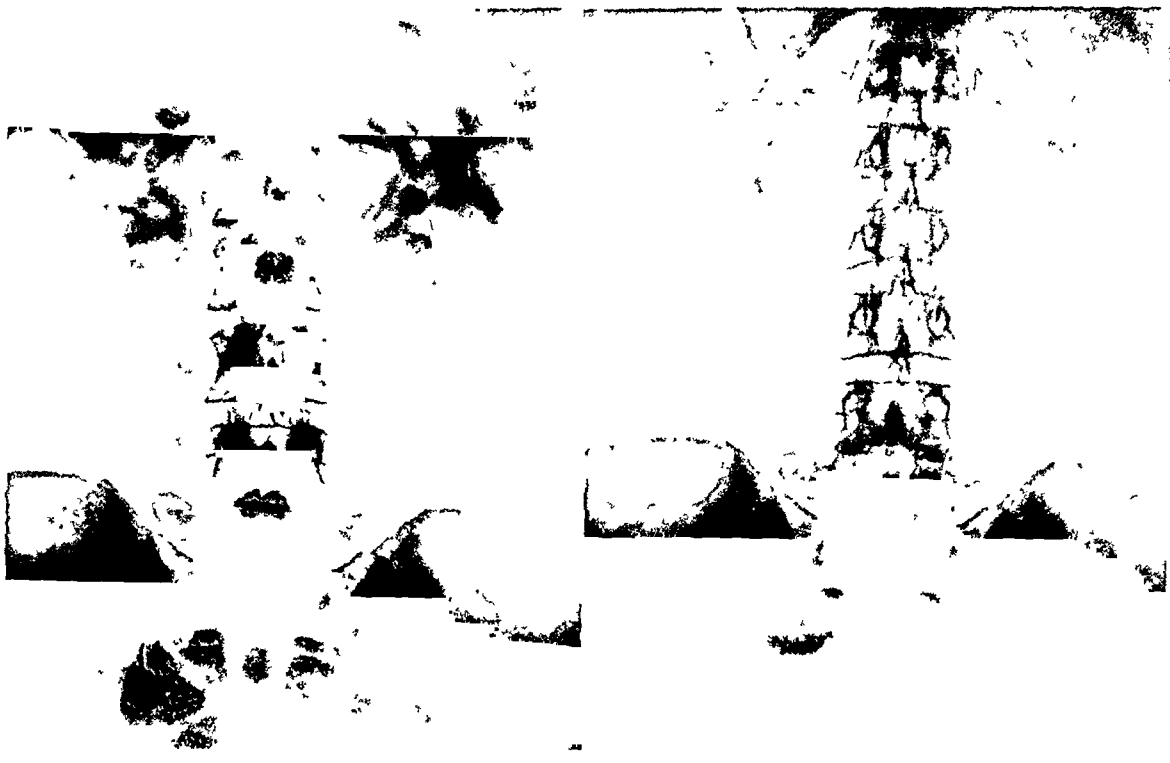
By I. SETH HIRSCH, M.D.

THE story of excretion urography really begins with the work of Rowntree and his associates, who in 1923 used sodium iodide intravenously for this purpose. They proved that intravenous urography was possible, feasible, and practical, if the proper chemical could be found. Several years later Roseno was able to show the urinary passages by the administration of a urea-iodine preparation, and though Ziegler and Köhler improved the visualization by external compression of the ureters, the radiographic contrast was not sufficiently graphic. Besides this, the substance was not well tolerated and was eliminated slowly.

The development of uroselectan as a contrast substance for intravenous urography is indirectly the result of research in the direction of obtaining a contrast medium for cholecystography. A substance called Selectan-Neutral, introduced by Bintz and Räth, which for some time had been in use as a therapeutic agent in infections of the biliary tract was investigated (because of its high iodine content of 54 per cent) as to whether or not it could be used for cholecystography. Though the biliary tract was not clearly outlined by this preparation, the urinary tract was so clearly demonstrated that experiments were undertaken by M. Swick, of New York, in the Clinic of Lichtwitz (Hamburg), with the view to making this drug applicable to urography. Swick found that 0.2 gram of Selectan-Neutral per kilogram of body weight was easily tolerated, and that as much as 18 grams of the substance could be administered without deleterious effects to a subject weighing 60 kilos. The kidney and bladder shadows were sufficiently distinct to indicate the possibilities of the method. However, whether the drug was administered by mouth or in-



Figs 1-*A*, 1-*B*, and 1-*C*. Illustrating the variations in appearance of urograms at first, second, and third examinations, made at intervals of twenty minutes. Fig. 1-*A* was made twenty minutes after injection; Fig. 1-*B*, forty minutes after injection; Fig. 1-*C*, sixty minutes after injection. The ureter on the left side shows marked hypertonicity. The right kidney is lower than the left. The urinary tract is morphologically normal. Function is normal on both sides.



Figs. 2-*A* and 2-*B* Illustrating the variation in appearance of the urogram at second (Fig. 2-*A*) and third (Fig. 2-*B*) examinations. In Figure 2-*B* the ureters are in systole and in peristalsis. Function is normal, and the urinary tract is morphologically normal.

travenously, there was headache, nausea, and vomiting.

It was apparent, therefore, that a modification of the preparation was necessary in order to so diminish its toxicity that larger quantities might be tolerated and a higher concentration obtained in the urine.

The removal of the methyl group diminished the toxicity and increased the solubility of the compound. Its iodine content was somewhat lowered, however.

This preparation, uroselectan, has been perfected by the chemists, Bintz and Räth. It fulfills all the requirements. It is nontoxic, easily soluble in water, and is excreted by the kidney in a concentration high enough to give the necessary roentgenologic contrast. The iodine content of 42 per cent exists in a stable, organically combined form. Under normal conditions, uroselectan is excreted as such to the extent of from 90 to 100 per cent through the urinary tract within eight hours, suggesting that probably no chemical reaction takes place in the body. The iodine component cannot be recovered in the blood. Neither in solution nor in its excreted form is the iodine present in an inorganic, ionized state. Because of this, in spite of the relatively large quantity of the calculated iodine element in uroselectan, it can be administered with impunity. Iodism has never been observed.

The method is based on the excretion of the contrast substance by the kidneys. The more normal the kidneys, the greater the excretion, and the earlier, the more constant and complete is the delineation of the urinary tract. Since about 90 per cent or more of the iodine content can be recovered





Figs. 3-*A* (*above*) and 3-*B* (*right*). In this case instrumental pyelography showed an aberrant upper calyx on the right side. A urogram made by the intravenous method showed a similar condition on both sides. Function was normal.

in the urine within from six to eight hours, in cases with normal kidney function, uroselectan becomes a test of renal function in addition to a urographic medium. This method may, therefore, be called "excretion urography" in contradistinction to "instrumental urography."

Urography with uroselectan permits: (1) visualization of the urinary tract; (2) the study of the physiology of the urinary tract; (3) the determination of kidney function.

The urinary tract as outlined by contrast substances has never really been studied under normal conditions in the living until the advent of this remarkable method. Instrumental urography, necessitating the introduction of catheters and fluids under more or less pressure, distorts and obliterates normal anatomic characteristics and relationships

The lack of uniformity in the morphologic characteristics of the ureter is one of the striking features which this examination has disclosed Loopings, bendings, narrowings, dilatations, and marked deviations in position, are very common findings

Intravenous urography shows for the first time the physiological functional variations and permits the study of tone and peristalsis of the ureter and pelvis of the kidney.

The criteria for diagnosis will be considerably amplified and elaborated by this method. Contrasted filling of the urinary tract is obtained when the particular part is in diastole: those portions of the ureters for the moment in systolic contraction are poorly visualized.

The conclusions regarding disturbed function are based on the time of visualization of the contrast substance and the degree of density of the shadow. The actual standard of density is arbitrary and depends on a comparison of the two sides and the general structural density as shown in the roentgenogram.

Sharp and clear visualization may be expected only when the kidney function is normal. Depending on the degree of parenchymal damage, there is poor or delayed or



Fig. 4. Urogram showing marked bending of right upper ureter; size and tonus normal; peristalsis normal. Ureters outlined to vesical junction; function normal.



Fig. 5 Urogram showing right hydronephrosis and marked tortuosity of dilated right ureter. Tone not lost. Peristalsis could be visualized. The left urinary tract was normal, as was function on both sides.

no visualization whatever. If there is no outlining of the pelvis and calices, it is either because there is no kidney or the function has been destroyed. Thus renal tumor, severe infection, and pyonephrosis give no visualization, while malformations in which function is maintained are clearly delineated According to von Lichtenberg and Swick, general lowering of the functional efficiency of the system, as in severe cardiac failure, may be responsible for non-visualization; nor was visualization obtained in some cases of peripheral urinary stagnation, with infection. In a case of almost complete urinary obstruction by stone and infection, there was, at first, no visualization; but when, fourteen days later, the infection had partially subsided, the tract was well outlined. In cases in which there is no infection, as in hydronephrosis, good visualization is obtained.

INDICATIONS FOR INTRAVENOUS UROGRAPHY

1. In cases in which anatomical and pathological obstacles exist for cystoscopy, ureteral catheterization, or instrumental pyelography.

2. In cases in which there is ureteral obstruction and the pyelographic solution cannot be injected beyond the obstruction.

3. In cases in which instrumental pyelography is definitely contra-indicated or not convenient.

Intravenous urography should be used in those cases in which cystoscopy and ureteral catheterization are difficult or impossible, namely:

(a) In urethral strictures, severe bladder disease, and severe bleeding.

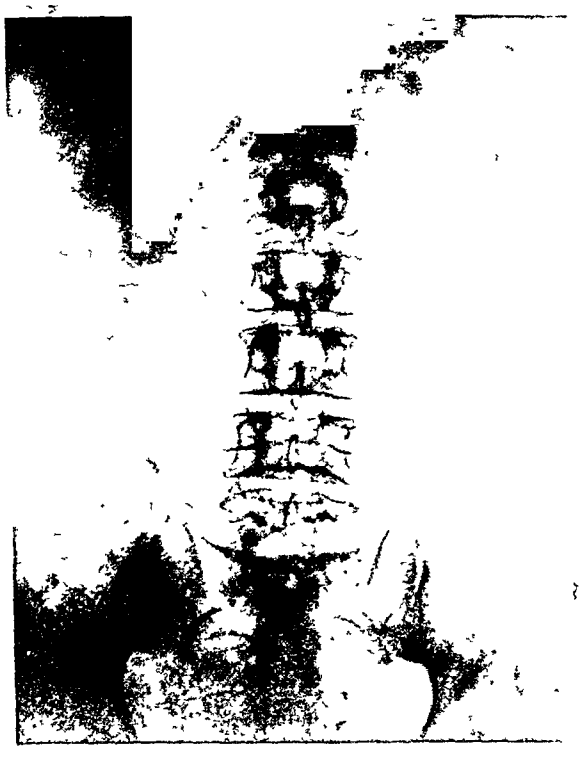


Fig. 6. Urogram showing enlarged hydronephrotic kidney on right side. On left side no kidney function; no visualization.

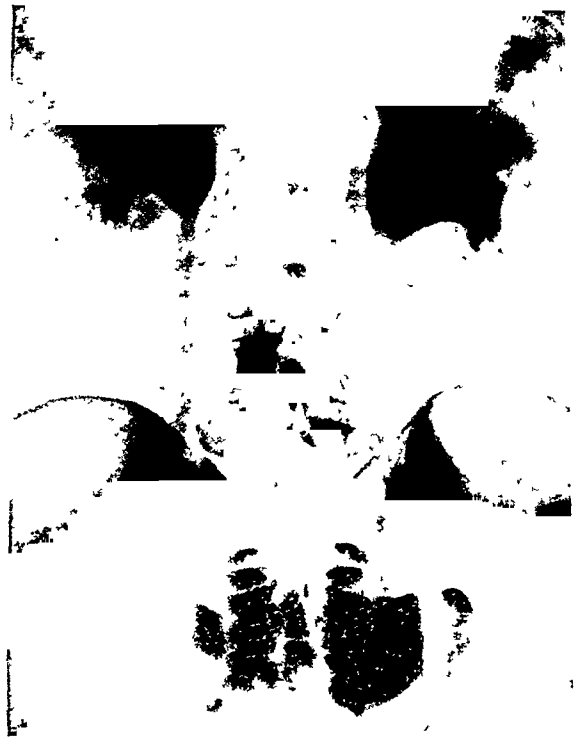


Fig. 7 Urogram showing marked dilatation of pelvis and calices on right side; hydronephrosis; dilatation of ureter. On the left side similar conditions existed in a lesser degree. Function on both sides was normal.

(b) In cases in which the ureters cannot be catheterized and in which catheterization gives no definite information; in cases of ruptured kidney; in fistulæ; in cases in which the ureters have been transplanted.

(c) In those cases in which instrumental pyelography should not be done—in acute and chronic disease of the adnexa, in tuberculosis, in cases of prostatic hypertrophy.

(d) In infants and children.

TECHNIC OF INTRAVENOUS UROGRAPHY

The technic of intravenous urography is extremely simple. The drug uroselectan is a powder put up commercially in forty-gram packages. The forty grams are completely dissolved by gradually adding it to 80 c.c. of previously heated, double distilled water. The volume is then made up to 110 cubic centimeters It is filtered twice and then sterilized by heating it over a steam bath for twenty minutes. The solution, cooled to body temperature, should have a volume of 110 cubic centimeters. For obese patients, 60 grams are necessary. Three packages are then dissolved in 220 c.c. of water, and 110 c.c. of the solution is used for a case. When cooled, the 110 c.c. is injected intravenously in two parts, with a syringe, allowing a brief interval between injections. The injection is made in the X-ray department by a member of the department's staff. The simple procedure of the injection needs no elaboration. The patient has a sensation of warmth, particularly over the face and vesical regions. The subjective sensations are not at all uncomfortable—it is only to avoid any possible discomfort that the solution is injected in two parts. There is, however, no objec-

tion to injecting the entire 110 c.c. at one time. There are no after-effects whatever. After the radiographs have been made, the patient may resume his usual routine. The methods of oral and rectal administration give results inferior to those which may be obtained when the drug is administered intravenously.

The preparation of the patient is the same as for the usual roentgen examination of the urinary tract. The bladder is emptied and a preliminary roentgen examination is made before the uroselectan is injected.

Though the concentration of uroselectan in the urine varies, it is usually about 5 per cent. The roentgenograms, even in normal cases, have not, therefore, the photographic contrast obtainable with solutions in use for instrumental pyelography. In cases in which there is kidney damage, this contrast is still further diminished. A slight modification of the X-ray technic may, therefore, be necessary for good contrast.

The technic includes the customary immobilization, the use of the grid, and the usual urinary tract "set-up." The routine 14 × 17 film should be supplemented by separate films of either or both kidneys, and the lower portion of the tract. Compression with the inflated bag or loofah sponge may be applied a short time before the exposures are made, though this is by no means essential. The roentgen study is a serial one.

The first urogram may be made fifteen to twenty minutes after the injection and a second exposure fifteen to twenty minutes later. The patient should be permitted to void after the second exposure. The withholding of urination over a long period is not necessary. Overdistention of the bladder hides the lower portion of the ureters. Three subsequent urograms may be made at intervals of fifteen to twenty minutes, making a total of five in all. If the visualization of the entire urinary tract on both sides

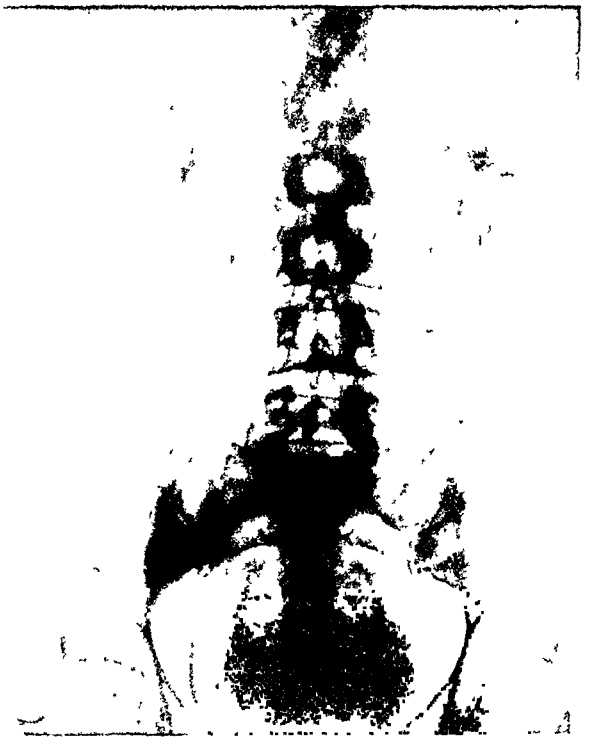


Fig. 8. Urogram showing double kidney and ureter on right side, the ureters fusing at a point about four inches above the bladder junction. The left side is normal. Function of the three kidneys is normal.

is clear and definite in the first or in the second film, this may be considered sufficient, and the examination be called complete. If, however, there is no visualization at first, it is necessary to make the entire set of five films.

In cases in which there is considerable renal dysfunction, clear visualization may not be obtainable until from six to twenty-four hours have elapsed.

It would appear that in actual practical work, three exposures, the first at fifteen, the second at forty-five, and the third at seventy-five minutes after the injection, will suffice.

The period of maximum visualization may be determined by fluoroscopic examination. Within five minutes after the injection the contrast substance may be vis

ualized in the kidney, but the tract in its entirety cannot be visualized before twenty minutes have elapsed.

This new method widens to a considerable degree the scope of the roentgenologist's function in urology. He is no longer dependent on the urologist for the instrumental procedure which was previously essential for urography. The roentgenologist now has at his command a safe and simple method for studying the urinary tract in countless medical and surgical cases in which the symptoms are not of sufficient gravity to indicate instrumentation and in which instrumentation is contra-indicated.

Intravenous urography will undoubtedly solve many urological problems without the aid of cystoscopy and ureteral catheterization, and will probably replace catheter pyelography as the method of choice. It will not replace the catheter for the determination of the source of blood and pus, nor for the segregation of the kidney urine. It may attain the status of a renal function test, but it will not do away with ureteral catheterization entirely.

A CONCEPT OF ARTHRITIS[1]

By LAURENCE H. MAYERS, M.D., Chicago

OUT of the great wilderness of pain the word "rheumatism" was born. It conveys an idea: it is not a diagnosis. Fortunately, it satisfies the less exacting laymen, but, unfortunately, too many members of our profession frequently submit it as a diagnosis to obviate a painstaking and skillful examination "Rheumatism" is the refuge of careless doctors, who frequently learn too late that pain is a symptom of malignancy. Joint troubles are inevitable when joint conditions become chronic. From this fact there has developed a bewildering nomenclature, irrational ideas of etiology, confusing attempts at pathological classifications, and a mass of therapeutic hodge-podge, unrivalled by any disease except tuberculosis When pulmonary tuberculosis was "consumption," glandular tuberculosis was "King's evil," and joint tuberculosis was "white swelling." Miasma was the cause and the King's touch the cure.

In our thinking concerning chronic infective arthritis, we are not far removed from the idea of the King's touch. It was only in 1907 that Nichols and Richardson, finding interest in the subject of arthritis from a pathological viewpoint, produced a series of observations which have remained classical in their description, and for a long time to come will form the basis upon which the condition is studied They were not interested in the treatment, but they did reach the conclusion that, whether or not it was hypertrophic, atrophic, or mixed in character, all manifestations were infectious in origin, and were probably caused by the same organisms

The number of classifications of arthritis is almost as numerous as the number of men who have made a study of the condition. We claim nothing new, other than perhaps our approach to the practical business of diagnosing and treating arthritic conditions. We accept the classifications made by various workers as correct.



Fig 1. Streptococcic erysipelas of the face

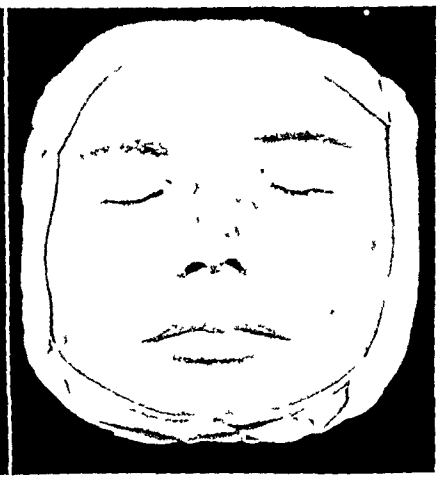


Fig 2 Lupus vulgaris of the face



Fig 3 Syphilis, papulosum lenticularis

[1]Read before the Radiological Society of North America at the Fifteenth Annual Meeting, at Toronto, Dec. 2-6, 1929



Fig. 4 Erysipelas perstans.



Fig 5 Lupus vulgaris.



Fig. 6. Syphilis papulosa

When studying and treating chronic diseases we must be cautious in arriving at conclusions. We must keep in mind that there are but few healthy persons, and as investigators of particular conditions we must not be misled by our findings. Many obscure factors enter into the cause of disease, which, though obscure, may be very real. Identity of lesion does not signify identity of cause, and there are some peculiar facts unexplained in symbiotic relationships.

The streptococcus causes many diseases and sometimes causes the train of symptoms and physical findings designated as arthritis. One may say that a patient suffering with a chronic streptococcic infection becomes physiologically old, regardless of age. Joint lesions, especially cartilagenous lesions, may have relatively slight power of repair, and with any method of actual cure, the functional restoration is impossible. The pathology of streptococcic infected tissue tends to progress, with long periods of remission. Many enthusiastic claims of cures in reality but represent these remissions.

The history of a typical arthritic patient frequently does not give a clue to the focus of infection. Inasmuch as the loss of immunity to streptococcus carries with it a loss of immunity to many potentially pathogenic inhabitants of the upper respiratory passages, the identification of the focus is frequently obscure and sometimes impossible, as a result of allied infection. Chronic infective arthritis may be defined as a chronic disease, caused by infection from various strains of bacteria. Usually it is a streptococcus infection. The general symptoms are



Fig 7 Purpura hæmorrhagica



Fig 8 Tuberculotoxin

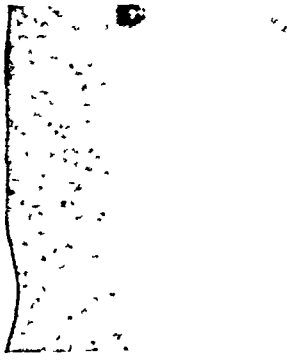


Fig. 9. Syphilis maculosa



Fig. 10. Purpura hæmorrhagica.



Fig. 11. Lupus vulgaris

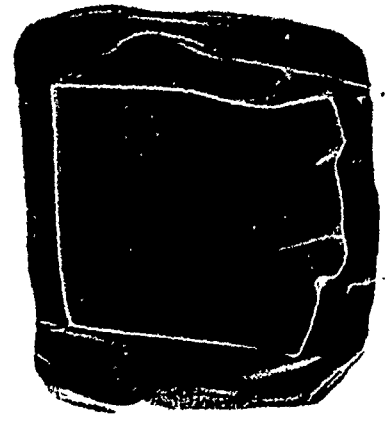


Fig. 12. Syphilitic lesions of face.

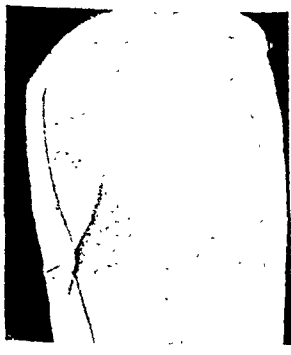


Fig. 13. Scarlet fever.



Fig. 14. Tuberculous toxemia of skin.



Fig. 15. Syphilis.

toxemia, fatigue, physical and mental depression. The pathological changes are progressive disturbances of muscles, nerve sheaths, articular, and peri-articular struc-

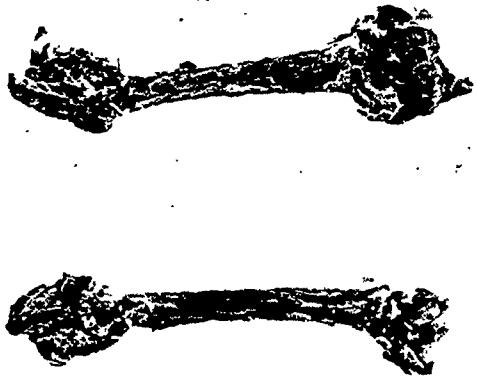


Fig. 16. Acute streptococcic infection, arthritis.



Fig. 17. Acute proliferative arthritis, streptococcic.

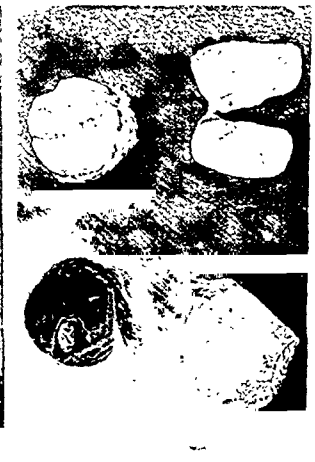


Fig. 18. Degenerative arthritis, due to syphilis.



Fig 19. Proliferative arthritis



Fig 20 Advanced proliferative arthritis



Fig 21 Arthritis deformans

tures The local results from these changes are pain and atrophy of soft tissue, together with hypertrophy and atrophy of joints.

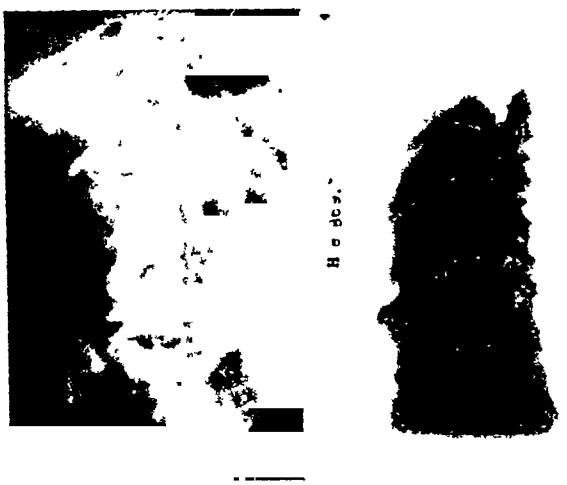
This leads us inevitably to the matter of focal infection In approaching this subject, it is well to definitely differentiate between *the focus of infection* and *focal infection.* The focus of infection should be understood, according to Billings, as circumscribed areas of tissue infected by microorganisms. It may or may not be related to focal infection. Focal infection further implies, according to Blum:

(1) That there exists or has existed a circumscribed lesion or focus;

(2) That the lesion is or was of bacterial nature and therefore capable of dissemination;

(3) That from the focus there has resulted systemic infection or intoxication of contiguous or remote tissue.

Hence the causative organism of chronic



Figs 22-*A* and 22-*B* Streptococcic infection of spine



Figs 23-*A* and 23-*B* Tuberculous spine.

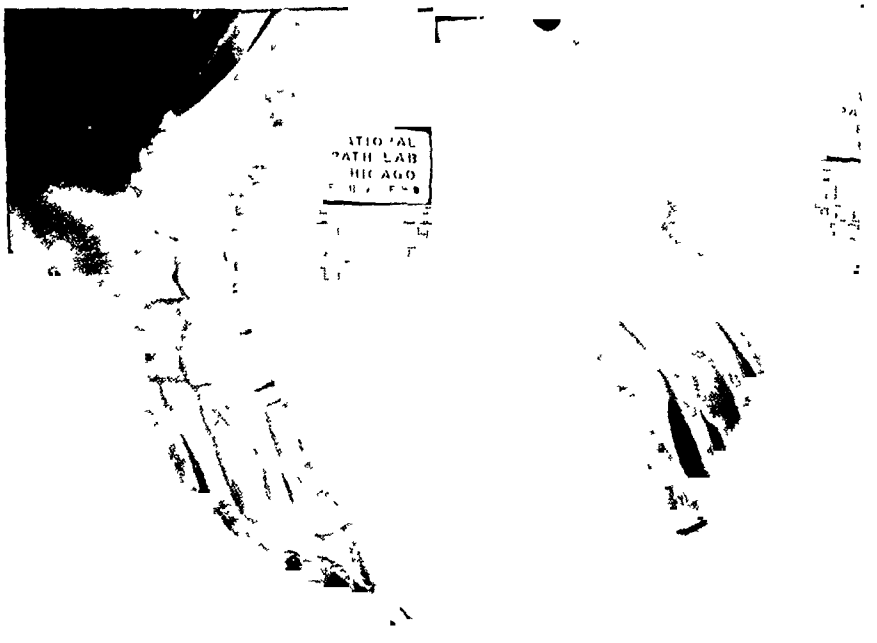


Fig 24. Charcot hip.



Fig. 26 Tuberculosis of carpal bones and head of ulna.

infective arthritis is a focal infection, just as, in a broad way, syphilis or pulmonary tuberculosis is focal. In many cases the focus of infection may have been healed long ago, while the disease resulting will be the effect of a general dissemination of the causative germs or their toxins. Hence, we must conceive of the disease known as chronic infective arthritis as a disseminated general infection or intoxication and that it has existed as such long before the pathological changes came about to dominate the clinical picture. In fact, the diseases known as hypertrophic, atrophic, and mixed arthritis no more represent primary clinical entities than do syphilitic aneurysms and tuberculous hips represent primary clinical entities. One might go further and state that the removal of the foci of infection in a well established case of infective arthritis



Figs 25-*A* and 25-*B* Bone cyst of the third metatarsal.

will have little more influence on the disease itself than would amputation of the penis in generalized syphilis or the excision of the

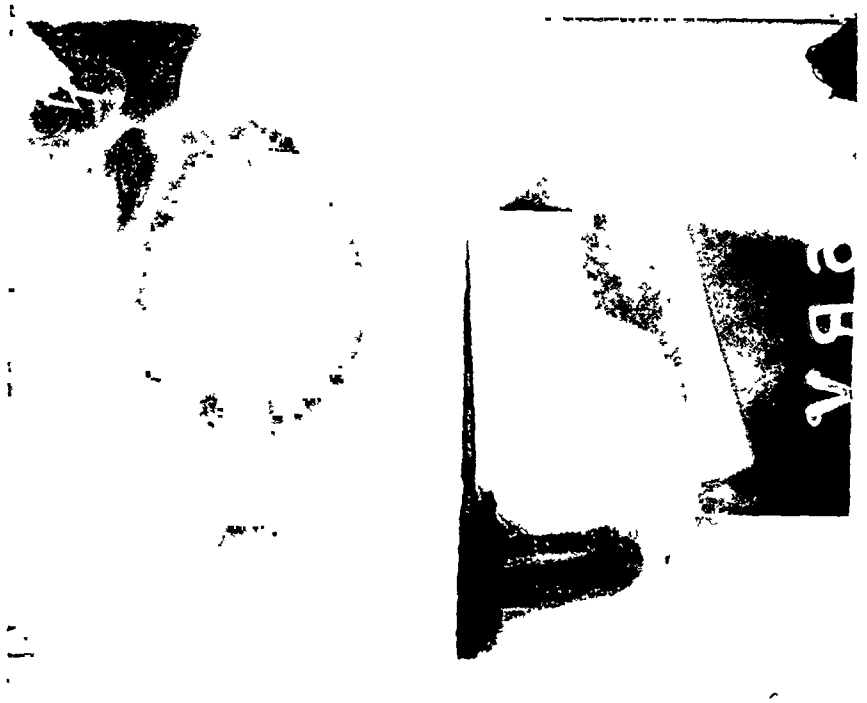


Fig 27 Congenital syphilis

upper lobe of the lung in generalized tuberculosis. This is not to be understood as meaning that the removal of infected tonsils will not be of benefit to the general wellbeing of a patient suffering as a result of infected tonsils or circumscribed areas of tissue infected with micro-organisms, but it does mean that the wholesale removal of tonsils, teeth, gall bladder, appendix, tubes, and uterus as curative measures in the treatment of chronic infective arthritis should be discouraged. We should not try to make our therapeutic measures more to be dreaded than the disease we endeavor to correct. Such measures are not indicative of right thinking on the part of the profession. Of course, when these ambulatory cases come in with their teeth removed, their tonsils out, and yet are no better—and the operation was done by a competitor—it shows that there has been very bad judgment The incidence of illness from rheumatism and heart conditions, cervical adenitis and ear conditions tends to be (1) lowest in children with normal tonsils; (2) higher in those with defective tonsils; (3) highest of all among those with removed tonsils. Presumably these more or less chronic conditions recover only slowly, if at all, after tonsils have been removed. In these, the dissemination has already taken place [2]

As we have said, chronic streptococcus infection attacks bones and joints, but it also attacks tendons and their sheaths, ligaments, fascia, muscles, and nerve sheaths. It attacks the structures in many degrees of intensity. Involvement of these structures produces pain far more frequently than is generally suspected. Simply the fact that our X-ray film shows a lipping of joint surfaces does not justify the conclusion that the pain is in the joint: it may or it may not be. An X-ray film may reveal bone changes of long duration and those changes may be

[2] From the *Public Health Bulletin*, July, 1927, p 175

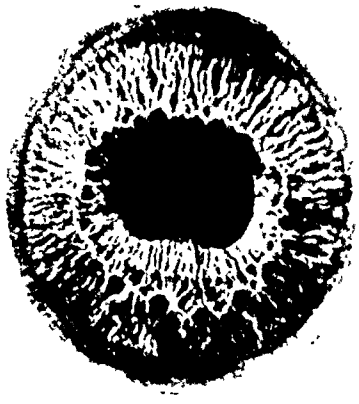


Fig. 28. Acute iritis.



Fig. 29. Tuberculous iritis.

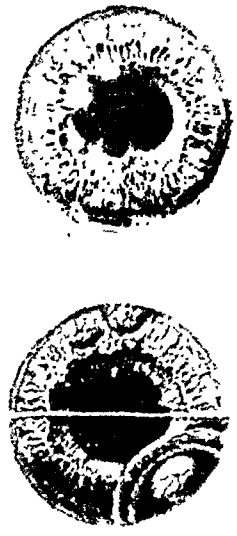


Fig. 30. Syphilitic iritis.

symptomless. On the other hand, the pain may be relieved spontaneously and the bone changes progress. Too many abnormal joints are free from pain for us to reach positive conclusions. For example, the spine is frequently distorted to a very marked degree and that painlessly, while in the advent of some change, relatively obscure, the pain may be very intense and prolonged.

In our treatment of these conditions we have come to the conclusion that the disease known as arthritis is a chronic infective condition, in which the joint manifestations are the end-products of a long period of intoxication, which intoxication results from an infective process. We endeavor to combat this intoxication by the use of vaccine. We know that vaccine treatment is an empirical treatment, but if we administer any treatment with favorable results, controlling our zeal with intellectual honesty, we may have the sanction of scientific minds. By the nature of things, science is truth, yet with knowledge incomplete, we do not know all of the truth. So long as this condition exists, empiricism will live. Disease germs are relatively harmless in a healthy body, and, given an unhealthy body, we may get an approach



Fig. 31. Tuberculosis of head of metacarpal, middle finger.



Fig. 32. Brodie's abscess of head of humerus.



Fig. 33. Charcot wrist.

to the borderline cases, the obscure infections, by the use of the complement fixation or agglutination tests, using these tests as an index to health or disease. The value of vaccine treatment depends upon whether or not the bacterium used is pathogenic for the individual. If vaccines are made from strains fixed by the patient's serum, the results obtained are favorable.

In treating chronic infective arthritis, we are dealing with a non-self-limited disease, comparable only to syphilis and tuberculosis. In order to approach the problem of any of these conditions, it is necessary to envision the problem as a whole, and so, lacking any more definite picture in the line of therapeutics, the vaccine treatment appears to be the most logical. We cannot cure any of these diseases by attacking the affected anatomical systems, since the diseases are general. Of the three, streptococcic disease is most frequently encountered and its problem least often solved. We cannot but feel that if pulmonary tuberculosis were not a menace to public health, and if, in acknowledging syphilis, a man did not have to confess a sin, the problems presented by these two diseases would to-day be as unsolved as is that of arthritis. We may confine a tuberculous patient in a sanatorium lest he be a menace to public health; we can keep a patient with syphilis under our care for an indefinite period, because he does not care to tell his secret to any more physicians than necessary, but an arthritic will wander from one to another for an indefinite period, seeking always for an easy road to health. Specific vaccine treatment does not hospitalize him, is given by the hands of a physician, and can be carried on over a period of time with very favorable results.

In order to demonstrate the similarity and the multiplicity of lesions in various tissues of the body, we have prepared a series of illustrations to which your attention is directed. Up to and including Figure 21 they are arranged in the order of three, the one to the left being always the streptococcic lesion, the one in the middle the tuberculous lesion, and the one to the right the syphilitic lesion.

DISCUSSION

DR. E. L. JENKINSON (Chicago): During our career as roentgenologists, our contact with disease lies to a great extent with the three great, non-self-limited conditions —syphilis, tuberculosis, and general arthritis. As a branch of the profession of medicine, we occupy a peculiar place, in that our opinion, if of a positive character, must of necessity carry with it a distressing conclusion. This is particularly true with arthritis. In tuberculosis and syphilis, the underlying condition is usually diagnosed prior to our employment. This is not true with arthritis, especially among those of us who are doing a large amount of industrial work. Unfortunately, it becomes our duty to sound that differential note between injury and disease. In giving that opinion, we are carrying a great responsibility. We cannot diagnose pain from a plate, and yet we are called upon to tell whether a given condition is disease or injury. If we call it injury,we may be imposing a long period of compensation, with hospital charges, upon the shoulders of an employing organization or an insurance company. If we call it disease, we are imposing a non-compensative diagnosis upon an injured employee. Hence, we are constantly in danger of being harassed by our own consciences, in the fear that by turning our opinion one way or the other, we may be doing someone an injury.

Lipping of joints does not necessarily cause pain. The tearing of a ligament may not cast a shadow on a film. With both present, it is our duty to decide which is the definite factor.

In listening to this paper we should all feel relief that finally arthritis is being approached from a causative, rather than a

therapeutic viewpoint. Our observation and our experience have taught us that, with the hospitalization of an injury with a concomitant arthritis the therapeutic measures are frequently worse than the disease; that the application of body casts, traction, demoralizing splints are frequently disciplinary measures and that the unfortunate patients, after submitting themselves for an inadequate period of time, choose to go on suffering from the disease rather than undergo the punishment which was designed and is necessary for their relief.

We should all hope for evidence of wiser judgment toward the problem of arthritis, and that the broad twilight zone of disease, characterized by fatigue and pain and various other subjective symptoms, may yield to definite diagnosis, and that the objective conditions, such as joint changes and resulting deformity, may be anticipated.

Arthritis has its quiescent stages, just as do syphilis and tuberculosis, but with this difference: Tuberculosis and syphilis are susceptible to diagnosis, while the remissive stages of arthritis may be heralded as a cure. If physicians are able to diagnose arthritis by serological methods, before the destructive processes have developed, a new phase will have been reached in the practice of medicine, and our work as roentgenologists will be relieved of a great deal of responsibility, in that we shall be asked to make our diagnoses from an objective viewpoint only, and our interpretations will not be made to yield themselves to subjective interpretation, with possible injustice to some one.

DR. C. S. WRIGHT (Toronto, Ont., Canada): With regard to the causative factors and treatment of arthritis, I would say that in our experience here, with Dr. Smith and myself at the Orthopedic Hospital, where we handle a good deal of arthritis, our approach has been directly along the lines Dr. Mayers has discussed. I would say this, in slight differentiation, that our experience is that removal of foci, if carefully examined and diagnosed, will contribute about 70 per cent of cures. Along with removal of foci we use vaccines, autogenous if possible. When we cannot get autogenous vaccine, we often try mixed vaccine. We are not always able to get sensitization work done, but even in those cases in which we use vaccine not directly from the foci of the patient, I think the thing we must watch is to use a dose small enough. We feel that about 70 per cent of the cases are curable and the other 30 per cent have foci that are not easily removable, as from the intestinal tract. The best approach I know of at the present time is by the older methods of elimination. Of the newer methods, perhaps the most exact is colonic irrigation, and after that modification of diet. We use special diets with the idea of modifying the bacterial flora and improving the vitamin and natural salts, and in that way eliminating foci. Perhaps I should not say with that idea only, but primarily with that idea, and it very often works. The diet must include a fair proportion of raw foods, fruits, and vegetables. The other element, of course, is going back to very old therapeutics again, to supplement those specific diets with foods that simply promote general health and upbuilding of that personal resistance which contributes to immunity. We not infrequently find quite elderly patients, sixty and sixty-five years of age—women, with all their joints involved, who respond and get perfectly well. I think these are not just exacerbations which have become quiescent, for we follow these patients over a period of years and they get well and stay well.

I have the greatest admiration for the way Dr. Mayers has expressed his views on this subject, and I think he is entirely right, and I believe we will reach definite results in ar-

thritis by taking seriously the observations that he has made.

DR. JOHN HUNTER (Toronto): I think the first thing we should consider is heredity. We should find out all we can about the origin of our patient, the type of tissue with which he was born, his environment, his childhood, his youth and middle life, his vocation—all these things contribute to either susceptibility or to immunity. I think the great factor in the treatment of this disease is to establish immunity, that is, through physical means such as diet, physiotherapy, electrotherapy, and every way in which we can increase immunity to disease. I have listened to a great many papers and I have been impressed by the fact that seldom has any reference been made to the patient—it is nearly always to the focal trouble. Put your X-ray and radium here, there, and everywhere; but we seem to have forgotten the patient. I think the patient is the first consideration; his type and everything else is far above any local treatment. We may cure a diseased foot, but if the individual has some other trouble, we will learn of it in treating this rheumatic condition. I begin with the baby and watch him all the way along, as to diet, sunshine, and cleanliness. I watch his school days, his vocation, his shop, and everything I possibly can, to secure for him the best sanitary conditions in all his surroundings. In this way we may avoid arthritis in about 90 per cent of our cases.

DR. RALPH K. GHORMLEY (Rochester, Minn.): I was very glad to hear Dr. Mayers concur with me on tuberculosis and streptococcus infection. I think in our work it will help more and more if we study the singularity in the changes and types of changes in the joints themselves. So far as the actual cause is concerned, I do not believe we can lay it wholly to foci of infection; there are a good many things we do not know about it, particularly its chemistry. I believe the day will come when we will know more about the chemistry of the cells themselves of both the cartilage and the bone, and what these damaging factors do to those cells and from whence the products that cause the damage come. Focal infection has a good part to play, but I believe there are also metabolic changes, diets, etc., that produce the changes in the joint itself.

DR. MAYERS (closing): There are many things which contribute to the treatment of arthritis. I think I would be safe in saying that 30 per cent of cases recover spontaneously. The individuals who have had arthritis for twenty-five years will state that medical care has always been helpful and perhaps for a period of four or five years they have felt that the condition has disappeared, only to recur. In many cases, after the pain disappears, there is a time when most of the crippling and weakness take place, and that weakness is very profound and contributes to the permanent disablement.

Removal of foci of infection is frequently startling and spectacular in its results, yet four or five years later the arthritis may again appear and there will be no focus of infection found to be responsible.

In regard to metabolic changes, I do not see why the metabolism can be stated to have a definite relationship to this particular disease. We might ask, what are the metabolic changes of a patient who has had tuberculosis for ten years? After the first few years, having gone through the acute stage, if we follow the remission, we shall expect to find it altered.

The organisms which are responsible for arthritis attack just as many systems in the body as does tuberculosis, as I have shown here to-day. Certainly arthritis, as well as many chronic diseases, will alter metabol-

sm. We naturally employ any method available to improve the general condition of these persons—fresh air, sunshine, and heliotherapy will always be indicated.

So far as heredity is concerned, I have a feeling that this element plays a part in a great many diseases; in just what manner, we are not prepared to say. We may be able to look forward to the eventual coming of a racial immunity, such as we are discerning in the history of tuberculosis and syphilis, yet I doubt this very much. The etiological factor is too widely distributed and present in too many mild conditions.

RADIOLOGICAL EVIDENCES OF UROLOGICAL DISEASES IN INFANCY AND CHILDHOOD[1]

By PERRY B. GOODWIN, M.D.,
Radiologist to St. Francis Hospital, PEORIA, ILLINOIS

IN presenting this subject, it is our earnest desire to stimulate more interest in an undeveloped branch of medicine and surgery in infants and children, and to show its value to those concerned. Your attention is called to some of the outstanding —yet small—number of men in this country, who have made a study along these lines, namely, Hyman, Hinman, Stevens, Kretschmer, Beer, and a few others, including Patch, of Montreal.

The study of diseases of the urinary tract in infancy and childhood is receiving more and more consideration, and, as a result, great progress is being made in the recognition of these conditions in the young. Until the small caliber cystoscopes had been perfected, no real progress was made; a decade ago cystoscopy was considered rather a cruel procedure, hence no attempt was made to examine these young subjects in an efficient manner, as was done in the adult.

Very little to-day is said in text-books regarding the radiological study of urinary diseases or the diagnostic value of cystoscopy, radiography, or cystography. These possibilities were first pointed out by Nitze in 1907 and Beer in this country in 1911, and by Kretschmer and Helmholtz later. Such a co-operation between the urologist and roentgenologist is essential to the development and advancement of our methods of diagnosis.

For a long time it was considered that all we could do was to show a calculus, but by the development of the small cystoscope, opaque catheters and media, many pathological evidences have been shown on the film, and with the further development of our Bucky diaphragm and cystoscopic tables with radiographic equipment, this method of diagnosis has become less complicated. We realize that this subject should be strictly a radiological one, but we are so closely associated with the urologists that their help must also be enlisted. In fact, no branch of medicine can be properly studied without due consideration to the clinical history, and especially in the case of the young, one must consider the laboratory and cystoscopic findings, which are as important to us as our X-ray evidence is to the urologists. We must not lose sight of the fact that this co-operation goes far in the evaluation of the clinical picture. We must keep in mind the various contours produced by pathologic conditions and how to interpret symptoms as well as shadows on the films. We have to consider the disturbances of micturition, dysuria, frequency, enuresis, hematuria, pyuria, pain and swelling in one or both kidney regions. For instance, dysuria, with frequency, may be caused by *Bacillus coli* infection, urinary tuberculosis, calculus, or foreign body.

When one reads that pyuria shows a mortality of from 10 to 18 per cent, it behooves all concerned to study these cases, both in adults and children. In cases of chronic pyuria, we must look for a cause of the suppuration, as malformation, calculi, tuberculosis, tumor, abscess, hydro- and pyonephrosis. In order to obtain a definite picture of each case we must avail ourselves of cystoscopy, associated with catheterization of the ureters, and pyelography. Quite often the clinical signs are absent, and then we must employ roentgenographic methods to assist.

The kidneys of an infant are relatively larger than an adult's, but because they lack

[1]Read before the Radiological Society of North America at the Fifteenth Annual Meeting, at Toronto, Dec. 2-6, 1929.

the fatty capsule, and because a large amount of gas is present in the infant gastro-intestinal canal, the film of a young patient does not show the same definite outline of the kidney as does that of an adult. However, if we can show any evidence, for instance, of difference in the size of the kidneys, or any change in the contour of kidney outline, it may furnish the needful clew to the urologist. If there should be a shadow of a stone in a calyx, for example, it becomes important to the urologist to know the relative size of the stone, or whether or not it will probably pass down the ureter, or whether it is wasting time to prolong operation.

It is a fact that various lesions in childhood are the same as those encountered in the adult, though in the nature of things the carcinomatous type of malignancy and prostatic involvement are absent. Many of these young patients are treated with the hope that the condition will clear up, without subjecting them to the modern methods of diagnosis—cystoscopy and roentgenography

It is imperative to use all the evidence obtainable if we hope to recognize the true pathology early and prevent a later mortality. Children stand the examination well; in fact, our cases have not shown as much reaction as have adults. In many cases a brief anesthesia is indicated, which need be of short duration only, if the urologist is rapid in his observations. The indications for cystoscopic and radiographic examinations are the same in these patients as in adults, and they should be done just as thoroughly.

The increasing tendency towards periodical health and life expectancy examinations in children no doubt will direct attention to their genito-urinary lesions. As we remarked previously, the importance of cooperation with the urologist becomes evident in cases in which we are called upon to differentiate between lesions of the abdomen and kidney. We are often surprised at the number of cases which would have passed unobserved if it were not for the opaque catheter and media, and pyelograms especially, after the plain roentgenograms had proved negative.

The cystoscopic examination, with pyelograms, opaque catheters, and cystograms should be routine, unless contra-indicated by the presence of an acute infection or in cases in which the renal function has been markedly impaired.

Cystography is a valuable procedure, easily performed, for which no anesthetic is necessary, and gives valuable information in diseases of the lower urinary tract, often rendering cystoscopy unnecessary. It will reveal size, shape, and outline of the bladder, diverticula, ureteral refluxes, hydroureter, and hydronephrosis secondary to bladder obstructions.

Pyelography should be done cautiously, especially when the patient is under an anesthetic, because there is no guide to pelvic capacity.

There are several points of interest in radiologic and urologic study of pathology in infancy and childhood. First, it is difficult to elicit subjective symptoms, and second, it becomes more important to examine closely for objective signs. Pathology of the lower urinary tract presents such symptoms and signs as hematuria, tenesmus, dribbling, and enuresis. Anomalies of the genital system are often associated with anomalies of the urinary tract.

Urological diseases may be overshadowed by intestinal symptoms. Often the patient is treated for a pyelitis or cystitis, when surgery is indicated, urinary pathology being discovered only too late in the disease to prevent an early death, because advantage was not taken of modern diagnostic methods.

It is time we spread our radiographic teachings, so that the proper course may be taken with these young patients. It should be the rule that a complete urologic and

radiographic examination be made in the cases of infants and children, thereby preventing some of the mistakes. A cystogram, combined with a radiographic examination, is not difficult or dangerous, and gives more information than one might suspect; at least enough so that the patient can be given relief until time permits further examination. Such a study may call for the methods of cystoscopy, cystography, or ureteropyelography as necessary procedures—examinations which are just as safe, sane, and necessary in the child as in the adult.

Perhaps disease of the genito-urinary tract is not as frequent in infancy and childhood as in adult life; at the same time, if infantile cases presenting urinary symptoms and signs were given the same routine examination, we might demonstrate more pathology than is suspected.

Dr. Brown and Dr. Corbeille have made a study of eighty postmortem cases of the young taken at random: sixty-three would have started out with impaired renal function. This would indicate that urinary disease occurs more frequently than it is diagnosed. When there are persistent urinary symptoms, the routine examinations should be made, keeping in mind the upper urinary tract, because there may be a calculus that cannot be shown on the film. Cystography is very important in cases of pyuria, when it is difficult to clear the bladder. Some of the objective signs which require a routine study are: localized pain in the kidney or bladder, pus in a catheterized specimen of urine, abdominal tumor, enuresis, hematuria, and over-distended bladder.

CALCULI

These are more frequently found in the bladder than in any other part of the urinary tract, but may occur anywhere, from the kidney to the bladder. A roentgenogram should always be made of the whole urinary tract so as to detect any concretions higher up. In our opinion, this should be done previous to any other examination—in so doing we will find calculi to be more common than is suspected. Some calculi consist of ammonium urate or uric acid, both of which substances have poor opacity and therefore may escape detection, but if located in the kidney or ureter an opaque catheter often meets with an obstruction. If this be followed by the injection of an opaque medium, we may then note a dilatation above or below the shadow, or irregular and nodular dilatation at the site of the shadow. Often in these radiolucent calculi, the opaque medium will show more density than the calculus and cause a mottled area due to displacement of the opaque medium. In the absence of opaque medium above it, one should suspect a calculus.

Bugbee reported thirteen cases of renal calculi in infants under one year of age, found at autopsy. Renal calculi in children are bilateral in from 6 to 10 per cent of cases.

If pyuria has persisted for a long time, one should not overlook a calculus in the bladder or lower ureter. Obstinate cases of enuresis should always be examined for calculi. Roentgenograms should be made, even though some calculi do not cast shadows.

TUMORS

The presence of a large mass which may almost fill the abdomen, even if hematuria is not present, should be examined with the opaque catheter and pyelograms. However, we may not be able to outline the tumor because of the dilution of the opaque medium with retained fluid, or obstruction due to the abnormal course of the catheter; we will often find the catheter displaced, causing one to suspect a tumor mass. In renal pelvic tumors, the outline of the pelvic wall will be altered. Under the classification of benign tumors, we have cysts—they may be

small, multiple, or large solitary. The large benign solitary cysts are of much more diagnostic and surgical importance. The malignant tumors in this region are hypernephromas.

The embryonal neoplasms which are found in infants are quite distinct from tumors in adults. They attain a large size rapidly, often completely filling the abdomen. Pyelography is of particular assistance in such cases, because there is a marked tendency of practically all renal neoplasms to invade the pelvis; as a result, the outline of the pelvis is irregular, with encroachment on parts of its circumference and a cup-like extension about the tumor mass. These appearances must be differentiated from the erosions, with enlargements of the calices typical of tuberculosis, and the very irregular pelvis of infection and elongated congenital polycystic kidney. Plain roentgenograms may show the kidney to be enlarged and the outline to be irregular. However, it is difficult to distinguish the different types of tumors, because there are no dependable signs. Generally the child will have, associated with a mass in the abdomen, weakness and malnutrition. In tumors of the bladder, roentgenograms are of little value if the growths be small, but when they are large and indurated, a shadow may be seen on a plain film; however, the cystogram, with opaque medium, is of the greatest value in showing the size and position of the tumor. Copious bleeding in a child under five years of age, with other clinical features characteristic of a tumor, and (generally) shadow on the film, is enough to diagnose renal sarcoma.

RENAL TUBERCULOSIS

This is not common except as a generalized body infection. Braasch reported only two such cases in children under ten years of age among 532 cases of renal tuberculosis. The changes which one will note on a pyelogram are strictures of the ureters, necrosis of cortex, dilatation of the pelvis, deformity in the outline of the calices—such as a fuzzy or moth-eaten tip—loss of the cup-like appearance, which often appears as though the calices were separated from the pelvis. It is the belief that laboratory findings with a guinea pig inoculation are necessary.

HYDRONEPHROSIS

Many of these cases are congenital, due to pathology in other areas besides the kidney, such as strictures or kinks at the uretero-pelvic junction. Bugbee found fifty-three cases in a series of 4,000 autopsies, in which only one-third of the infants had lived more than six months. Hydronephrosis is often bilateral, due to obstruction in or below the bladder, and unilateral when obstruction appears in only one ureter. Of obstructive causes we mention incomplete strictures, slow growing tumors which press on the ureter, and calculi. Early changes may be seen on the pyelogram—the cupping disappears, the calices become globular, the pelvis becomes greatly dilated, often with an associated hydro-ureter, especially if the obstruction is in the bladder. The urologist should carefully and completely fill the dilated pelvis and ureters.

PYONEPHROSIS

This is a dilatation of the renal pelvis resulting from an inflammatory change in its walls. Here we find general irregularity, dilatation more noticeable in the calices, with a clubbing of the ends. When the inflammatory process extends farther, it causes destruction and necrosis. The necrotic areas may fuse with the calices, whereupon the pyelogram will show an irregular appearance of the kidney substance.

HYDRO-URETER

This is caused by obstruction of a variable degree—the longer the duration of the obstruction the greater the dilatation. The

lower the obstruction of the ureter, the greater will be the dilatation adjacent to it. The dilatation may extend upward until it dilates the calices, a condition more noticeable in bladder obstructions.

When the pelvic outline is irregular, one should suspect the presence of inflammation, such as is caused by tuberculosis. Calculi may not be shown, but often, when the ureter is injected, we find a dilatation above a certain point, in which case there is a chance that it is caused by a calculus, especially if the presence of tubercle bacilli cannot be demonstrated. A tumor in the lower abdomen may cause pressure in the ureter and produce a dilatation.

There are many causes of hydro-ureter into which the writer will not go at this time, mentioning only such conditions as chronic stricture and cicatricial constrictions due to infection or injury.

VESICAL DIVERTICULA

With a continuous obstruction, diverticula may be produced by internal pressure. These diverticula may reach an enormous size or be very small. They are generally to be found by the cystogram, especially if taken at different angles or stereoscopically after the bladder has been filled with an opaque solution. After draining the bladder of the solution, another cystogram should be taken, which will nearly always show retention of some of the solution in the pockets or diverticula. Such pouches are usually congenital in origin, but we believe they really have their beginnings in obstructions, though these may have occurred during fetal life.

ANOMALIES

Anomalies are not infrequently met with, and doubtless many unsuspected cases exist. On postmortem studies they are reported to be present in a percentage ranging from 1.5 to 2.5, but it is likely that when more cases displaying urological signs and symptoms are studied, the percentage will be much higher. Many of these anomalies are found in the upper part of the urinary tract and lead to hydronephrosis and pyonephrosis. Before children are subjected to operative procedure we should be sure that there is a second kidney. Double kidney should be suspected if the pyelogram shows an abnormally placed single pelvis, in relation to the whole kidney outline. A pyelo-ureterogram should be made to demonstrate fused ureters, where only a single orifice is seen in the bladder.

POLYCYSTIC KIDNEY

Congenital polycystic kidney may be due to failure of union between the tubules, causing a cyst to form. The condition is generally bilateral. The cysts are mostly in the parenchyma, the kidney being enlarged in all directions, the effect most marked in the longitudinal diameter of the kidney, while the calices may be spread apart. On the pyelogram one notes that the calices are encroached upon, while contour and sharpness of outline remain; they may be short, broad, irregular, or obliterated. The pelvis is narrowed and elongated, but never dilated —this is an important sign.

In the forty-two cases of which Dr. Arthur Sprenger, urologist, and the writer have made a complete urological and radiographic study, they discovered 1 case of renal tumor (patient two years of age); 7 ureteral kinks; 1 bilateral polycystic kidney (patient two years of age); 1 congenital stricture (patient 13 months of age); 1 probable sarcoma; 5 strictures of the ureter (the ages of the patients ranged from five to seven years); 1 congenital infected hydronephrosis; 1 calculus in ureter (in patient six years old).

CONCLUSIONS

1. The main object of this brief paper is to increase interest in such urological

diseases during infancy and childhood as show radiographic evidence.

2. These young patients are amenable to the best methods of examination, and an earlier diagnosis has a share in lowering the mortality rate from urologic diseases later in life.

3. Cases of infants and children who present symptoms or signs pointing to the urinary tract should have a complete examination.

4. The most important evidence we have is that produced in roentgenograms.

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EDITORIAL

M. J. Hubeny, M.D. *Editor*
Benjamin H. Orndoff, M.D. . *Associate Editor*

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DIAGNOSIS OF URETERAL KINKS AFTER INTRAVENOUS MEDICATION

Now that visualization of the urinary tract by intravenous medication is possible, there is sure to be an increasing demand for urograms. Therefore, the radiologist should beware of faulty reasoning from effect to cause. This error is never made in diagnosis with greater danger than in the case of the patient with unexplained abdominal symptoms, who is found to have a kinked or angulated ureter. The presence of acute angulation of the ureter in one who complains bitterly of pain that is referred apparently from the ureter presents such a likelihood of relationship between cause and effect that it is difficult for the clinician, and sometimes impossible for the surgeon, not to fall into this trap. When a patient returns several months after operation, the previous symptoms persisting, it becomes evident that kinks of the ureter occasionally occur in the presence of pathologic changes elsewhere.

The kidney and the ureter are held in position by entirely different supports. The ureter, which is attached to the posterior peritoneum, is fixed, whereas the kidney, under normal conditions, has considerable freedom of motion. Consequently, at the point where the ureter leaves the peritoneum to cross posteriorly to the renal pelvis the ureter can become kinked when the kidney moves with respiration. It is evident, therefore, that if the roentgenographic exposure is made at the command to "take a deep breath and hold it," there will be a much larger incidence of ureteral kinks than if the exposure is made following expiration, when the kidney is in its cephalic position.

If the minor calices of the kidney are clear-cut, and if there is no evidence of dilatation of the renal pelvis, one must be cautious about attributing any symptoms to the kink in the ureter. Before a kink can produce pain, it must have resulted in urinary obstruction. Even a moderate amount, if intermittent, soon results in dilatation above the obstruction.

Seventeen years ago Childs and Spitzer wrote: "Angulations, curves, and kinks of the ureter are found in normal persons. As the shape of the ureter is due to its laxity or tenseness, either of which conditions may be normal, and its caliber varies considerably in normal subjects, and as it is still further altered by peristalsis, care should be exercised in drawing conclusions that pathologic conditions exist because of apparent abnormalities of shape and course or because of curves, kinks, and angulations or apparent constrictions."

Childs and Spitzer's observation has stood the test of seventeen years of increasing study and knowledge and is particularly applicable at this time, when it seems that the entire urinary tract can be visualized after intravenous medication.

Hermon C. Bumpus, Jr., M.D.
Gershom J. Thompson, M.D.

THE ANNUAL MEETING

Los Angeles, California, Dec. 1–5, 1930

On behalf of the Radiological Society of North America, the Los Angeles Local Committees extend to radiologists the world over a hearty invitation to be present at the Society's Sixteenth Annual Meeting.

Ordinarily in the early winter the climatic conditions in Los Angeles are very pleasant. The Hotel Ambassador, our headquarters, is delightfully situated and well adapted to the needs of a meeting such as ours.

Committees are busily engaged in working up an entertainment program which, while not distracting too much from the scientific character of the meeting, will, we hope, at least furnish pleasant relaxation and prove of sufficient interest to warrant your participation.

From present indications, it appears that the coming meeting will be a good one, well attended and representative of the Society.

Please consult the list of committees in the September issue of RADIOLOGY, and write to the Chairman of any of them if detailed information is desired.

ALBERT SOILAND, M.D.

Chairman, Local Executive Committee.

ANALES DE RADIOLOGIA

True to Cuban medical traditions, the comparatively small group of Cuban radiologists are the proud publishers of the only radiological review in the Spanish language, *Anales de Radiologia*, official organ of the Sociedad Cubana de Radiologia y Fisioterapia. It is handsomely printed, classically written, and generously illustrated. In many an article, the author backs up his academic dissertation by the practical procedure of case presentation, thus giving his essay the seal of originality. The writer feels that *Anales de Radiologia* is a publication capable of honoring any radiological organization, of any size, in any language.

RADIOLOGY, through the undersigned, wishes to acknowledge, with thanks, the salutation of the Executive Committee of the Sociedad Cubana de Radiologia y Fisioterapia, appearing in the first number of *Anales de Radiologia*, and hopes for their splendid publication a long and prosperous life.

P. R. CASELLAS, M.D.

BOOK REVIEWS

STORY OF ELECTRICITY AND A CHRONOLOGY OF ELECTRICITY AND ELECTROTHERAPEUTICS. By HERMAN GOODMAN, B.S., M.D. With an Introduction by VICTOR ROBINSON, M.D. Pages 62; full-page portraits, 12. Published by Medical Lay Press, New York, 1928.

Dr. Goodman has written a short history of electricity, with special emphasis on the cycles of development, particularly as regards electrotherapeutics. The short biographical sketches of many of the pioneers in this vast field lend much to the interest and value of the book, while the portraits help to visualize what these pathfinders looked like.

This book is written in readable style and your reviewer has found it so interesting and full of important historical data that, instead of giving it a casual examination, for the purpose of review he has read it through twice.

The "Chronology of Electricity and Electrotherapeutics" from 600 B. C. to A. D. 1927, covering five pages, is interesting and valuable. The only error your hypercritical reviewer has found is that 1893 is given as the year Röntgen announced the discovery

of the X-rays: but this is given correctly (as 1895) in the biography of Röntgen.

It is a valuable collection of practically all the known data, condensed into small and convenient form, and should be in the library of every radiologist.

I. S. TROSTLER, M.D.

THE EFFECT OF ROENTGEN IRRADIATION ON THE INTERRELATION BETWEEN MALIGNANT TUMORS AND THEIR HOSTS. By CARL KREBS, M.D. Supplement VIII to *Acta Radiologica*. Stockholm, Sweden, 1929: 133 pages and 3 plates. Price, $6.90.

This excellent monograph is a summary of the author's investigations of the effects of lethal and lower doses of X-rays on a mouse carcinoma and sarcoma. He shows that for these tumors only doses of more than 6 H.E.D. are lethal, both *in situ* and *in vivo*; that doses lower than this produce only inhibition of the tumors, and that preliminary irradiation increases the power of the organism to resist tumor subsequently implanted subcutaneously in the exposed region.

This work gives a clue to the answer to many of the puzzles in roentgenotherapy, and merits thorough study by both the radiotherapists and biologists.

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ARTHRITIS

Sciatica. A. P. MacKinnon. Can. Med. Assn. Jour., April, 1930, XXII, 492.

The object of this paper is to show that all the features of idiopathic sciatica can be accounted for by an infectious lumbosacral arthritis. Hence, in cases where such arthritis can be proved to exist, the sciatica should not be classed as "idiopathic," but as "symptomatic" of arthritis.

The paper is based on and is an appreciation of the work of Danford and Wilson, who published in the January, 1925, issue of the *Journal of Bone and Joint Surgery*, the results of an extensive anatomical study of the bony relations of the sciatic nerve. They showed that on anatomical grounds the neurological findings of a typical case of idiopathic sciatica can be accounted for by a neuritis of the fifth lumbar root. They also found that the anatomical relations of this fifth lumbar root are such that osteo-arthritic changes, in the region of the lumbosacral articulation, would compress it and produce sciatica.

In the X-ray examination of every patient complaining of sciatica good films are important. They should consist of stereoscopic films made with the vertical shift, and a lateral. Gross lesions, such as lumbosacral tuberculosis, newgrowths, spondylolisthesis, and osteo-arthritis of the hip must be ruled out. The X-ray examination should concentrate first on lipping of the bodies of the vertebræ. Such a finding would suggest associated changes in the adjacent articulations. These latter should then be studied closely. Lumbosacral anomalies should be investigated. Finally, negative X-ray results do not rule out the ordinary infectious arthritis which shows no bony changes in the early stages.

L. J. CARTER, M.D.

BONE (DIAGNOSIS)

Epicondylitis Humeri. K. G. Hansson and I. D. Horwich. Jour. Am. Med. Assn., May 17, 1930, XCIV, 1557.

Better known as "tennis elbow," this has been a subject for investigation since 1896. Described as a well defined clinical entity, with marked pain and tenderness above the elbow, it occurs after a great muscular exertion or some continuous labor. The symptoms follow such games as tennis, polo, baseball, and squash, or such occupations as pressing clothes with heavy irons, typewriting, bricklaying, carpentry, or painting. It apparently offers little evidence from the roentgenographic standpoint. The antero-posterior and lateral roentgenograms are negative; some observers have reported roentgenographic evidence of a periostitis.

The authors' concept of the pathologic condition is that of a periosteal fracture with a myofascitis of the extensor muscles which originate from the external epicondyle.

No treatment is of any avail unless the extensor muscles from the external condyle are relaxed.

C. G. SUTHERLAND, M.D.

Destruction of the Os Pubis by a Lymphangioma. E. Saupe. Röntgenpraxis, May, 1930, II, 469.

A case is described in which a roentgen examination showed an area of destruction in the right pubic bone. The patient, an adult male, had a spindle-cell sarcoma of the thyroid. The bone destruction, however, was not caused by metastasis but by a lymphangioma, which was found at autopsy.

H. W. HEFKE, M.D.

A Case of Sclerosing Osteitis Involving One Limb. Eugenio Milani. Archivio di Radiologia, January-February, 1930, VI, 70.

The author reports a case of sclerosing osteitis which he has followed for more than a year. The thickening was along the internal margin of the right femur, and was accompanied successively by small areas of thickening of the tibia and the astragalus.

This lesion was first described by Leri and Joanny in 1922. Other cases have been reported by Lewin and MacLeod (1925), by Putti and Muzii, Perussia and Meda (1927), and by Zimmer and Valentin (1928). It is interesting because of its possible relationship

to that form of chronic osteomyelitis first described by Sicard and Ragueneau in which the increased density is limited. Its radiologic appearance is characterized by the involvement of the whole or part of the length of the member by the hyperostosis and by the fact that the lesion may cross the joint onto adjacent bones. All cases occurred in the young. The lesion is frequently confused with osteomyelitis.

E. T. LEDDY, M.D.

Unilateral Duplication of the Patella: A Congenital Anomaly. Max Climan. Med. Jour. and Rec., June 4, 1930, CXXXI, 558.

This anomaly, when it occurs, is usually on both sides and can thus be diagnosed from fracture with certainty. It is occasionally unilateral and has been mistaken for fracture. The differentiation depends on the observation that in congenital anomaly the fragment is smooth, with cortical bone, while in fracture it is serrated and is cancellous bone. The separate fragment in the case of anomaly is in the upper and outer quadrant in all reported cases, while this is rarely the seat of fracture.

W. W. WATKINS, M.D.

CANCER (DIAGNOSIS)

The Age Incidence of Carcinoma. Theo. R. Waugh and T. L. Fisher. Can. Med. Assn. Jour., May, 1930, XXII, 619.

The material from which these statistics were gathered comes from the broad hospital service of the Royal Victoria Hospital, Montreal, and includes outdoor minor surgery, general surgery, urology, gynecology, otolaryngology, etc. The figures are obtained from the records of the Department of Surgical Pathology, and cover a period of fourteen years, from 1915 to 1928. Only carcinomata positively diagnosed by microscopic section are included. The only cases reported are primary malignant epithelial tumors.

During the period from 1915 to 1928 a total of 22,993 surgical specimens were examined, of which 1,756, or 7.63 per cent, were primary cancerous growths; 63.6 per cent were from females, and 36.4 per cent from males. The average age of all the cases was 53.5 years; that of the females 50.6 years, and that of the males 56.5 years. The age incidence showed a gradual increase from age 25 to age 50, was constant from 50 to 65, and then gradually decreased. This decrease after 65 does not represent less liability to cancer after that age, but simply represents the fewer persons who reach that age. The regional incidence shows breast cancer largely predominating.

Generally it was found that carcinoma arising from glandular epithelium tends to occur earlier in life than that arising from squamous epithelium. To this rule there are two main exceptions, namely, the cervix and the prostate, both of which derive their epithelium from the mesoderm. The squamous cell carcinoma of the cervix occurs chiefly in the early period of life, while the carcinoma of the glandular prostate occurs chiefly in old age.

L. J. CARTER, M.D.

Statistical and Systematic Studies on the Malignant Tumors Observed during 1928. Ferruccio Vigi, Giovanni Dagnini, and Giuseppe Mareggiani. Rivista di Radiologia e Fisica Medica, March, 1930, II, 221.

This excellent study concerns 775 autopsies performed on 1,666 patients dying in the hospitals of Bologna, in which series there were 104 malignant tumors. This article should be consulted in the original by those interested in clinical cancer research.

E. T. LEDDY, M.D.

Primary Carcinoma of the Lungs. Pedro L. Fariñas. Anales de Radiologia, January, 1929, I, 47.

The paper is based on twenty-six cases of primary carcinoma of the lungs in which the diagnosis was established either by biopsy, necropsy, or clinical course. Many radiographs and photographs of the specimens are shown. The author classifies these tumors as infiltrating or nodular encapsulated—the former arising either from the hilum or from the parenchyma, the latter being always of parenchymatous origin. The differential diagnosis

between these tumors and non-malignant conditions of the lungs is discussed.

The author emphasizes the fact that carcinoma may follow chronic diseases of the lungs, accompanied by metaplasia of the bronchial epithelium, and makes the suggestion that these cases should be observed by serial radiography, with the hope of making an early diagnosis.

M. VIAMONTE, M.D.

CANCER (THERAPY)

Treatment of Mammary Carcinoma by Radiation. Sir G. Lenthal Cheatle. Brit. Med. Jour., May 3, 1930, No. 3617, p. 807.

The two objects of the article are, first, to describe how pathological observation shows that the whole of the breast itself should be radiated in carcinoma of that gland, and, secondly, to describe the method the author adopted in delivering interstitial radiation to a breast containing carcinoma. He then opens the paragraph on biological effects of radiation by stating that the treatment of carcinoma by this method is in an exceedingly tentative and experimental state, and believes that at present we are judging our results from the effects of doses that may be a great deal too large and administered for too long a period at a time. For if little or no result is seen from a given dose, larger doses are employed, when, for all that is at present known, smaller doses frequently delivered in short periods at frequently repeated intervals may be more successful. Moppett is quoted as having isolated wave lengths that retard growth and those that stimulate growth, and believes that a proper manipulation of the wave lengths that retard growth may replace all other forms of radiation therapy.

The author then discusses what is meant by (1) external and interstitial radiation, and (2) the radiosensitivity or radioresistance of tumors. While it is certain that the regression of a tumor after radiation depends on the effect on the tumor cells, there is also a considerable amount of evidence that another factor involved is to be found in the reaction of the tissues in which the tumor lies. This is thoroughly discussed and experimental evidence from the literature is given. The author takes nearly a page to give his reasons for radiating the whole breast in carcinoma, as well as the axillary and cervical regions, and from the stress that he places on this, one would judge that this is not being done by radiologists of the author's acquaintance, a technic quite different from that of American radiologists by whom the necessity of radiating the whole breast is more or less taken for granted.

A paragraph on clinically undetectable tumors is of considerable interest, and examples of such cases are given. In one of these the tumor of the breast could not be detected by clinical examination, and was discovered only during complete microscopical examination of whole sections. This was done because a tumor removed from the right axilla had been shown microscopically to be carcinoma in a lymphatic gland.

Cheatle then discusses radiation *versus* radical operation, and again emphasizes the necessity of including the axillary, supraclavicular, and intercostal regions, and the subcutaneous tissues of the chest in every case, no matter how localized to the breast the disease appears to be. His statement that radical removal of an operable carcinoma of the breast will always be safer than an inadequate radiation of the gland is only too true. He discusses his technic for interstitial radiation, and states that, as the result of five cases, he has been able so far to support the convictions of G. L. Keynes, who believes that interstitial radiation is the operation of choice in the treatment of early carcinoma of the breast. The author uses the same principles and technic as Keynes, that is, small units of radium with heavy filtration.

H. J. ULLMANN, M.D.

X-ray and Radium Treatment in Cancer of the Cervix. W. M. Sheridan. Southern Med. and Surg., June, 1930, XCII, 411.

In determining whether or not a woman has cancer of the cervix, bimanual examination, visual inspection of the cervix, and biopsy should all be employed. Cancer confined to

the cervix may be eradicated by X-rays and radium or by the Wertheim operation. Panhysterectomy should not be performed, and when the disease has spread beyond the cervix the Wertheim operation is of no value.

The technic advised is to give deep X-ray therapy over the lower abdomen and back, each side, and perineum, at 200 K.V., 0.5 mm. copper filter, 50 cm. distance, 5 ma., over each area except the perineum, which receives half of this dose. After two weeks' time any cauliflower mass which has not disappeared is destroyed by electrosurgery. Radium is then applied by embedding in the cervix and by application within the cervical and uterine cavities. Four 10 mgm. needles are embedded and left for 24 hours, and 50 mgm. tubes are placed in the cervical canal and uterine cavity for 24 hours, the filtration being 1 mm. of brass and 1 mm. of rubber or aluminum.

W. W. WATKINS, M.D.

Cancer Therapy with Fractional (Scattered) X-ray Treatments. G. Miescher. Strahlentherapie, 1930, XXXVI, 434.

The time factor deserves more consideration in radiation therapy than it has been given so far. The work of Regaud and Coutard has shown this very convincingly. Better results in roentgen therapy of malignant tumors may be obtained if the technic used in radium therapy is imitated, *i.e.*, if small doses are given over a long period of time. Coutard, for instance, treats his cases one to two hours daily at 40 to 50 cm. F.S.D. through 1.5 to 2.0 mm. Zn over areas of 100 to 250 sq. cm., with very small intensities. The duration of treatment extends from 15 to 20 hours, distributed over 14 to 40 days, and the total dose amounts to from 12,500 to 37,000 French r-units. The skin reactions were relatively mild.

Miescher conducted a series of animal experiments along these lines and then tried the method in treating human carcinoma. If the effect of roentgen rays applied to the ear of a rabbit in fractional doses (400 r each) was compared with that of one single high dose, an increase in the tolerance was already noticeable, with a three-hour interval between exposures. When allowing a 24-hour interval to elapse between the fractional doses the tolerance increased two and one-half to three times. Longer intervals did not influence the toleration further. On 26 patients it was shown that daily doses of from 200 to 240 r may be applied up to a total of 4,000 r, without producing serious injuries during a period of two years' observation. The acute reaction appears usually on the sixteenth day and is over on the forty-eighth day; erosions are often observed. In one patient who had an involvement of the left cervical muscles, the reaction following the application of 3,740 r given in 17 daily doses of 220 r each through 2.0 mm. Zn over a 17.5 $\times$ 14 sq. cm. field, could be studied histologically for 91 days. Twelve biopsies were performed on the 5th, 10th, 15th, 20th, 27th, 31st, 37th, 44th, 50th, 57th, 70th, and 91st days.

It appeared that the reaction corresponded to that of an intense treatment applied in one sitting; however, the changes in the connective tissue were considerably less. This is, in the author's opinion, the most important advantage of the fractional method. In many advanced cases of carcinoma the response of the tumors was remarkable, and further study and perfection of the method are indicated. For skin carcinoma of small size the application of a single massive dose still remains the method of choice.

E. A. POHLE, M.D., PH.D.

On Radiation Therapy in Cancer. A. T. Todd. The Lancet, April 26, 1930, CCXVIII, No. 5565, p. 906.

The author reviews briefly the theories of specific action on cancer cells, radiosensitivity, etc., and believes that some of his experiments appear to furnish evidence against the specific action of radiation on cancer. He believes that the regional response to radiation therapy is the important reaction. The hypothesis is that the local defense mechanism against cancer is probably the junction tissue, that is, the mesoblastic defense barrier, which tries, apparently in vain, to limit the spread of the

growth. This tissue is not well known and its possible significance has not been appreciated. It consists of lymphoctyes, plasma cells, monocytes, and macrophages, various phases of fibroblasts, eosinophile and basophile leukocytes, and the blood and lymph channels. The slowly growing cancer has much of this junction tissue while quickly growing cancer has little. This junction tissue is frequently termed the stroma.

Todd offers an example to show that radiosensitiveness of a tumor is directly proportional to the amount of this junction tissue. The general defense against cancer is also of importance, and evidence for this is obtainable from the behavior of implanted cancer in animals, and from clinical observation of cancer patients treated by medical methods. He then states that successful treatment of cancer in man is accompanied by definite changes in the blood—increase of small lymphocytes and eosinophile leukocytes—and a diminution of that lipase which can split tributyrin. There is also evidence for the participation of the reticulo-endothelial system in the general defense mechanism. When the activity of the system is diminished or paralyzed by blockade, that is, when every cell has completely filled itself with the particles of an electro-negative colloid extracted from the blood stream, the implantation of cancer is facilitated.

A page and a half is devoted to arguments and experimental evidence that the stroma and general defense mechanisms are the important factors in the favorable reaction of malignant tumors to radiation. The author admits that there is plenty of evidence that radiation affects the cancer cell itself adversely, probably by inhibitory action on mitotic division, and thus prevents the continuity of growth. He considers that this immediate action is of less importance than, or even perhaps produced by, the mediate action of radiation which takes place locally in the junction tissue, a stimulation of its defense, and generally in those parts of the mesoblastic tissues which are concerned with defense mechanisms, especially certain cells of the blood and the reticulo-endothelial system. He believes that acceptance of these views will be followed by further modification of radiation technic in the direction of smaller doses applied for longer times, or at repeated intervals, and also with greater screenage. A fresh viewpoint may help to prevent the disappointment for which the current conception of radiation and the resultant technic are responsible.

H. J. ULLMANN, M.D.

Radium Therapy of Carcinoma of the Vagina. Iwan v. Büben. Strahlentherapie, 1930, XXXVI, 503.

It is often difficult, if not impossible, to differentiate primary and secondary carcinoma of the vagina. Only cases in which the neoplasm is confined to the vagina itself and does not involve the neighboring organs can be classified under that heading. The author observed 29 patients suffering from primary carcinoma of the vagina, 28 of whom were treated by X-rays and radium during 1919 to 1929. The radium dose of 1,200 to 2,400 mg.-hrs. was usually applied in one sitting and, if necessary, repeated after from 6 to 8 weeks. Nine patients were alive at the time of writing this report. Four patients lived 9, 6, 4, and 2 years, respectively, following the treatment; 5 patients had been treated less than 2 years previous to the report. Six women lived from 1 to 3 years following irradiation; 12 patients died within one year, and 1 case could not be traced.

E. A. POHLE, M.D., PH.D.

THE CHEST (DIAGNOSIS)

A Clinical and Roentgenologic Consideration of Pulmonary Infarction. B. R. Kirklin and Louis S. Faust. Am. Jour. Roentgenol. and Rad. Ther., March, 1930, XXIII, 265.

All the signs and symptoms of lodgment of a pulmonary embolus can occur without the development of any physical or roentgenological signs, for unless some degree of passive congestion is present infarction is not apt to take place.

The usual clinical findings are sudden onset of dyspnea and pain in the chest, with a moderate elevation of temperature, pulse, and leu-

kocyte count, and usually with hemoptysis. Roentgenologically, the infarct presents a large triangular shadow, with its base toward the axillary line, and usually with associated clouding of the costophrenic angle. There may be so much surrounding inflammation as to make the infarct indistinguishable from a pneumonic process. Occasionally the infarct shadow is round, which indicates that the base is lying anteriorly or posteriorly.

In 25 cases studied roentgenologically at the Mayo Clinic, there were definite X-ray changes in all cases with definite physical signs, and in several with indefinite physical findings. In 18 of the cases the infarct was at the base of the right lung, while in 4 cases infarcts could be demonstrated in both lungs. Clouding of the costophrenic angle was almost invariably present. Thickened pleura was the commonest complication. At times the pneumonic changes were so marked as to make the condition indistinguishable from bronchopneumonia.

In certain cases old unresolved infarcts may be demonstrated by the roentgenogram when physical signs are no longer present.

J. E. Habbe, M.D.

Roentgenologic Diagnosis of Diseases of the Upper Respiratory Tract in Children. Henry K. Pancoast and Eugene P. Pendergrass. Am. Jour. Roentgenol. and Rad. Ther., March, 1930, XXIII, 241.

The authors believe that all children referred for chest X-ray study should have a simultaneous examination of the oropharynx and neck by erect and prone lateral film examination, made both at the end of crying inspiration and at the end of expiration, with the head so held midway between extension and flexion so that the neck is straight with the body. A modification of the chair used for encephalography is used for taking the film in the erect position. On the lateral views the arms are held down and back of the chest. With the exception of the detection and localization of foreign bodies, nearly all the information of pathological neck conditions is to be obtained from the lateral view.

All of the following structures in adult life and many in infancy and childhood can be visualized on the lateral neck films: pharynx, posterior border of tongue, uvula, epiglottis, arytenoid cartilages, aryepiglottic folds, superimposed pyriform sinuses, the vestibule of the larynx, the ventricular folds, ventricles of larynx, cricoid cartilage, lower extremity of the larynx, and the trachea.

In five cases of post-diphtheritic stenosis of the larynx, all showed narrowing of the subglottic region of the trachea.

In tuberculous conditions the most significan X-ray finding is calcified cervical glands.

Retropharyngeal and retrotracheal abscesses are quite easy to diagnose by properly taken neck films, and show a decided increase in thickness of the soft tissues anterior to the vertebral bodies.

With regard to the thymus question, the authors follow the belief of Chevalier Jackson, that in many instances the thymic menace is one of mechanical tracheal compression, and, therefore, they advocate the lateral film as being of most value in showing tracheal narrowing at the thymus level, particularly since Jackson states that thymic tracheo-stenosis is worse in the erect posture. The thymus usually does not obstruct because it is wide, but because it is thick. In pathologic enlargement of the thymus one may show the following on the lateral view: narrowing of the thoracic inlet air space on inspiration, too great collapse on expiration, buckling of trachea at either phase, and (on sagittal view) lateral deviation of trachea.

J. E. Habbe, M.D.

About the Relationship between Bronchiectasis and Tuberculosis. Georg Simon. Med. Klin., June 6, 1930, XXVI, 852.

During his work in a tuberculosis sanatorium the author has paid particular attention to the occurrence of bronchiectasis in combination with tuberculosis. He has seven times seen small bronchiectasis, only demonstrable by Iodipin contrast filling, together with healed "primary complexes." Four times he could follow up the development of bronchiectasis in active tuberculosis. A chronic tuberculosis may lead to bronchiectasis rather

frequently, probably through mixed infection of the bronchial tubes and the pull of the scar tissue. The question of how often tuberculosis in infancy and childhood may lead to bronchiectasis must still be left open.

H. W. HEFKE, M.D.

Broncholiths, with Report of Four Cases. John J. Lloyd. Am. Jour. Med. Sci., May, 1930, CLXXIX, 694.

Broncholiths are probably not as uncommon as the number of reported cases would lead one to believe. They arise from a deposit of calcium salts in bronchiectatic cavities, from sequestra of a bronchial cartilage, and many arise in the lung tissue outside the bronchi proper. Chemically, they have the same composition as bone. However, microscopically, they do not have the same cell structure. Many authors consider them to be obsolete tubercles.

Chevalier Jackson divides lung stones into three classes: "(1) True calculi; (2) calcium deposits in tissues that sloughed loose and gained entrance into the bronchus; (3) pneumoconiotic, silicotic, or anthracotic material that has loosened by disintegration or suppurative liquefaction of the encasing tissues."

Samuel West gives the incidence as sixteen in a thousand cases of tuberculosis, but thinks that this is a high percentage.

The author collected eighteen cases from English literature since 1900, and adds four more cases of his own, with roentgenograms. These cases are very interesting and well illustrated. He feels that the erosion of a calculus into a bronchus may occasionally account for a post-hemorrhagic spread of tuberculosis as well as produce bronchiectasis, lung abscess, or empyema.

ROE J. MAIER, M.D.

X-ray Diagnosis of the Complications of Influenza. C. D. Enfield. Kentucky Med. Jour., May, 1930, XXVIII, 222.

The complications of influenza in which X-ray aid is most frequently invoked are those about the head and in the chest. Any suspected complication of influenza in the chest should be examined by X-ray, as this will frequently give information not obtainable in any other manner. Whether the lesion is empyema, free or encapsulated, or pneumonia—developing or fully developed—the X-ray will help materially in ascertaining the true conditions. The examination of the nasal accessory sinuses and of the mastoid areas by the X-ray should be routinely carried out, if there is any suggestion of infection in these.

W. W. WATKINS, M.D.

Contribution to the Radiologic Study of Pleuritis in Acute Pulmonary Diseases: The Reaction of the Contralateral Pleura. G. Giuseppe Palmieri and Giuseppina Urbani. Rivista di Radiologia e Fisica Medica, March, 1930, II, 149.

In all cases of acute affections of the lungs a reaction of the pleura can be demonstrated radiographically, even though it may be a very slight one. This reaction is characterized by a thin marginal opaque strip which may extend on the right side as far as the interlobar fissure. This strip is demonstrable not only on the affected side but is also frequently present in the opposite lung at the same metameric level, according to Palmieri. The clinical and radiologic findings are most likely a contralateral pleuritic inflammatory reaction.

E. T. LEDDY, M.D.

Tracheobronchial Adenopathy in Children. G. H. Withers. Southern Med. Jour., June, 1930, XXIII, 547.

In arriving at the true status of the bronchial nodes from the roentgenogram, there are certain hazards and limitations. The technic of McPhedran minimizes this, and in making and interpreting the roentgenograms the following facts must be kept in mind: The density of the nodes is similar to the structures surrounding them, and an uncalcified node will cast no shadow unless it is larger than the structure upon which it rests; enlargement of mediastinal nodes from acute infection will not record. Exposures must be synchronized with late diastole to avoid dis-

tortion from cardiac motion. Films in various positions are frequently required.

W. W. WATKINS, M.D.

The Roentgenological Appearance of Echinococcus of the Lung and its Differential Diagnosis. Hans Fetzer. Röntgenpraxis, May, 1930, II, 417.

One can distinguish a closed and an open type of echinococcus of the lung, open when the cyst is in connection with a bronchus. The closed type may easily be mistaken for a solid tumor, either primary or metastatic. The open type may be difficult to differentiate from an abscess or cavity of other etiology. Other clinical and serological examinations must confirm the diagnosis, but the radiologist should at least mention the possibility of this disease.

H. W. HEFKE, M.D.

THE CHEST (THERAPY)

Tracheobronchial Adenitis. Charles P. Emerson. New York St. Jour. Med., June 1, 1930, XXX, 651.

Along the lower trachea, at the bifurcation of the primary bronchi, and along the larger bronchi, are groups of lymph nodes which may play a large part in the pathology of chronic pulmonary disease. These nodes mark the starting point of many of the cases of so-called central pneumonia, or bronchopneumonia, so common during and after the influenza epidemic.

In the treatment of tracheobronchial adenitis the author has used moderate X-ray therapy with great success.

W. W. WATKINS, M.D.

Roentgenotherapy of Bronchial Asthma. Gastone Torelli. La Radiologia Medica, January, 1930, XVII, 16.

The author reviews the modern literature on bronchial asthma and refers to four cases treated by X-rays. This method is considered as indicated (*a*) when the cause is not known, and it is, therefore, impossible to adopt any specific therapy; (*b*) whenever the agent appears resistant to radiation, *i.e.*, tumefied ganglia, endocrine alteration, etc. It is not recommended in the presence of emphysema. The effect of X-rays may be explained (1) as a reducing action upon the tracheobronchial ganglia; (2) as a regulating action on the endocrine system; (3) as a complex stimulation on the neuro-vegetative system. The author advises radiation of the lungs and spleen—dosage 20 to 30 per cent. E.S.D., 100 to 150 sq. cm. in three or four days.

L. MARINELLI.

CONTRAST MEDIA

Normal and Pathologic Skialography. Filippo Rocchi. Rivista di Radiologia e Fisica Medica, January, 1930, II, 1.

The author discusses his method of X-ray examination of the salivary glands by the injection of iodized oil into Stenson's duct by means of a special syringe of simple construction. He describes and illustrates the normal image of the parotid gland, and shows some of its lesions, such as mixed tumors, stone, abscess, fistulas, and Hodgkin's disease. This method, which is harmless and without contraindication, may be of diagnostic value in diseases not only of the salivary glands but also of adjacent structures.

E. T. LEDDY, M.D.

Lipiodol Pelvic Cysts. A. F. Lash. Surg., Gynec. and Obst., July, 1930, LI, 55.

Since the beginning of the use of iodized oils as opaque media for roentgen examination of the uterine and tubal cavities, there has been present the question of the effect of these oils on the mucous membrane of these cavities and on the peritoneum when spill of the oil from the tubes occurs.

References are given of the experience in using iodized oils diagnostically and therapeutically without unfavorable reactions. Conversely, few reports are cited from the literature illustrating the dangers of the use of iodized oils in spite of asepsis and indications. The author reports such a case in detail and draws the following conclusions, made from an analysis of previous case reports and his

case: (1) In a case of uterus bicornis unicollis, bilateral chronic salpingitis and healed pelvic peritonitis occurred independently of the foreign body reaction produced by the presence of lipiodol in the pelvic cavity. The function of the tubes was not disturbed by the lipiodol as the patient was delivered of a full term child one year after injection. (2) In the presence of infections of the female generative tract, the use of iodized oils is contra-indicated, as their antiseptic properties have not been demonstrated. (3) In some individuals lipiodol may induce foreign body reaction in the pelvis, but it is also true that some specimens of lipiodol (free iodine) may be irritating to any peritoneal surface. (4) The great value of iodized oils in roentgen examination of the female pelvic organs should be appreciated, but due precautions in its use must be observed. It is suggested that the oils be tested for free iodine and that oil injections be used only in the absence of infections of the female generative tract.

D. S. CHILDS, M.D.

DENTAL RADIOGRAPHY

The Significance of the Dental Radiograph and its Interpretation. James F. Brailsford. Brit. Jour. Radiol., January, 1930, III, 19.

Because some patients are known to retain septic teeth for years without apparent harm, the constant danger of such teeth may not be realized. Septic teeth may be detected by the patient, or the dental surgeon by inspection and clinical tests, and by X-ray examination. In acute inflammation the patient's attention will be called to the disease process, although he may not be able to accurately localize the painful tooth. Chronic sepsis about the apices of pulpless teeth may give no symptoms, and may escape detection even after careful clinical tests. Such chronic sepsis in bone from which toxins are being absorbed should, however, show definite changes in the bone surrounding such lesions by radiographic study. It is the writer's belief that teeth not showing changes on a good radiograph and not painful (as from an acute process) can be considered as not the source of chronic toxic absorption. The author believes radiographic study should be made by an impartial observer, and emphasizes, in conclusion, that a radiogram may be so poor the most experienced cannot accurately interpret it, while on the other hand it may be good, yet convey little or no information to the observer.

J. E. HABBE, M.D.

DIATHERMY

Destruction of Tonsils by Diathermy. Warner Collins. Brit. Med. Jour., June 14, 1930, No. 3623, p. 1094.

Other non-surgical measures, for example, X-ray, radium, and electric cautery, have proved inadequate. The author combines true diathermy with fulguration. The area is first anesthetized with a cocaine spray anesthesia, using 1½ to 2 grains of the hydrochloride dissolved in two drachms of water. It is necessary to work with a temperature between 60 and 100 degrees C., and this is a predetermined constant for the controls of the particular machine. The active electrode is usually a small metal ball mounted on a curved ebonite holder, through which the insulated current is carried. A diathermy current of two amperes is adequate, the frequency of oscillations being about 500,000 per second. A glass tongue depresser is used. The current is not turned on until the active electrode is in contact with the tonsil tissue. The entire operation takes but a few seconds, the tonsil being killed by the production in its substance of heat which causes coagulation of proteins and boiling of tissue fluids. The active electrode is then withdrawn to allow sufficient arcing effectively to seal the smaller blood vessels.

W. D. MACKENZIE, M.D.

Treatment of Anal Fissure and Spasm by Diathermy. Frank Howitt. Brit. Med. Jour., June 28, 1930, No. 3625, p. 1168.

The author gives his technic and concludes that this method of treatment leaves no room for doubt but that it is a curative agent of considerable value. In acute cases, which are always attended with a considerable degree of

spasm, the blood supply to the underlying mucous membrane is cut off. This tissue anemia prevents healing and a vicious circle is thus produced. The object of diathermy here is to relax the spasm and increase the blood supply to promote healing.

The indifferent electrode used is the metal abdominal belt described by Cumberbatch. The active electrode is actually inserted into the anus, the size being gradually increased at subsequent treatments up to maximum dilatation. Daily treatments are recommended. In the treatment of chronic cases, the method by Dr. A. F. Hurst is used, giving a much more intensive application of diathermy, with the object of rendering the whole area flaccid and malleable, and then dilating the anal canal manually. A much greater degree of dilatation can be produced after diathermy than is possible without such application.

WALLACE D. MACKENZIE, M.D.

GALL BLADDER (NORMAL AND PATHOLOGICAL)

Joint Changes in Hemophilia. Thomas Canigiani. Röntgenpraxis, June, 1930, II, 511.

The author reports a case of hemophilia in a seven-year-old child, with severe joint changes. Very instructive X-ray films are reproduced, showing definite areas of bone absorption around several joints, atrophy of the surrounding bones, narrowing of the joint spaces, and deformities. One should be able to make a roentgen diagnosis of this disease even in clinically indefinite cases. The differential diagnosis from chronic arthritis, tuberculosis, and syphilis of the joints is not difficult, considering the above-named points.

H. W. HEFKE, M.D.

Our Experience with Cholecystography. Karl Gefferth. Röntgenpraxis, June, 1930, II, 495.

Intravenous injection of the dye is used by the author because the oral administration, in his experience, sometimes leads to gastrointestinal upsets, and does not seem to be as reliable as intravenous administration. Cholecystography appears to be a very efficient means of demonstrating the function of the gall bladder but it is not entirely reliable in the demonstration of stones. A roentgenologically normal functioning gall bladder cannot always clinically be considered normal. The author has seen patients with a diseased gall bladder showing roentgenologically a normal filling.

H. W. HEFKE, M.D.

Contraction of the Gall Bladder. Editorial. Jour. Am. Med. Assn., June 28, 1930, XCIV, 2066.

Bile is one of the important digestive fluids, being of particular significance in the digestion of fats in the intestine, where it not only stimulates lipolysis but also serves to dissolve the products of this reaction, thereby aiding the transport through the enteric wall into the body. Between meals the bile from the liver passes into the gall bladder, where it is concentrated and from which it is extruded immediately after food leaves the pylorus. It has been demonstrated repeatedly that fats are especially efficacious in causing a diminution in size of the gall bladder and the flow of bile from this organ into the duodenum; proteins have only a slight effect in this connection and carbohydrates none at all. It appears that the patency of the sphincter of Oddi is affected also by the presence of fat in the intestine and that it acts in a reciprocal manner with the gall bladder.

Recent observations constitute significant evidence that bladder bile is forced into the duodenum by the contraction of the muscles in the walls of the gall bladder. These observations emphasize the probability of an intrinsic mechanism in the contraction of the gall bladder. In no case did the gall bladder empty when fat was given parenterally. Obviously, the stimulus arises through the activity of a mechanism of which the duodenum is a part. Electrical stimulation of the pyloric part of the stomach brings about a contraction of the quiescent gall bladder though similar stimulation of the stomach, cecum, or small intestine, during active emptying after giving egg yolk, causing an inhibition and relaxation, with

withdrawal of bile into the gall bladder. There probably exists a reflex pathway from the splanchnic area to the gall bladder, though the probability of hormone stimulation cannot be disregarded.

The facts point to a large significance of the gall bladder in gastro-intestinal physiology, an argument against the indiscriminate removal of this organ.

CHARLES G. SUTHERLAND, M.B. (TOR.)

GASTRO-INTESTINAL TRACT (DIAGNOSIS)

Busi's New Radiologic Sign in Ileocecocolic Invagination. Mario Santoro. Archivio di Radiologia, January-February, 1930, VI, 207.

Santoro has found in three cases of ileocecocolic invagination the radiologic sign described by Busi in 1926. This sign consists of a more or less complete series of rings made by the barium mixture as it passes between the invaginated and the invaginating intestine, and which is distributed in the narrowed haustra of the invaginating portion. This sign is obtained by administration of the opaque medium by mouth. It is advisable to begin the radiologic examination of such patients with the oral administration of the opaque mixture, and at a second examination use the opaque enema. The three cases were operated on and there were found no alterations in the intestinal walls, from which finding one may place much stress on a spastic contraction of the sphincter of the cecum as an etiologic factor in this lesion.

E. T. LEDDY, M.D.

Obstruction of the Colon. George H. Stobie. Can. Med. Assn. Jour., May, 1930, XXII, 650.

Obstruction of the large bowel differs from obstruction of the small bowel in many ways. In the small bowel the obstruction is sudden and complete, whereas in the large bowel it is the culmination of a slowly progressive condition, usually malignant. So that in large bowel obstruction there is not only the acute condition to be relieved, but the underlying malignancy must be treated.

Cancer of the colon is not diagnosed in 60 per cent of the cases until some degree of obstruction occurs. Hence arises the need for early investigation of colonic disturbances. Increasing constipation, coupled with loss of weight, anemia, and a feeling of fatigue should call for thorough examination of the colon in the following order: (1) digital examination of the rectum; (2) stool examination; (3) procto- and sigmoidoscopic examination; (4) X-ray examination.

Treatment of colonic obstruction should proceed in several stages. Usually a cecostomy should precede excision of the growth.

Obstruction of inflammatory origin, such as from a diverticulitis, can be readily differentiated by the X-ray from malignancy.

Several case reports are cited by the author to illustrate the various conditions mentioned.

L. J. CARTER, M.D.

Chronic Obstruction of the Duodenum. Malcolm Thompson. Southern Med. Jour., June, 1930, XXIII, 487.

Little attention is given in text-books to chronic obstruction of the duodenum, although much has been written about it in medical journals.

The causes are usually adhesions and compression. It must be differentiated from gastric, hepatic, cholecystic, pancreatic, and renal disease, as well as other obstructive conditions of the intestine and other lesions of the duodenum. The roentgen ray is extremely valuable in diagnosis, but only those with experience in interpreting gastro-intestinal studies are competent to say whether or not a duodenum is dilated.

W. W. WATKINS, M.D.

The Roentgen Diagnosis of Gastrocolic Fistulas. P. Eichler. Röntgenpraxis, June, 1930, II, 517.

It is often impossible to demonstrate gastrocolic fistulas by the routine gastric examination. Two such cases are reported, both fis-

tulas having developed after a posterior gastro-enterostomy. Resort must be had to an examination of the colon by means of a barium enema, thus establishing the existence of a communication between the colon and stomach. A more instructive picture, however, may be obtained by giving a small amount of barium by mouth, and then filling the colon with air. The mixture of barium and air plainly shows the fistula.

H. W. HEFKE, M.D.

Intussusception: Diagnosis and Value of Early Operation. Harold H. Fox. Southern Med. Jour., June, 1930, XXIII, 509.

The diagnosis is established on the following points: (1) Most important is a carefully taken history from the mother; (2) a freely movable abdominal tumor; (3) blood passed by rectum; (4) vomiting; (5) rectal tumor; (6) negative blood and urine pictures, and lastly, (7) the determination of intestinal obstruction by use of the barium enema, fluoroscopic findings, and roentgenograms.

W. W. WATKINS, M.D.

The Duodenal Niche—A Criterion in the Healing of Duodenal Ulcer. Jacob Buckstein. Surg., Gynec. and Obst., July, 1930, LI, 109.

An historical survey of the significance of the niche in the healing of gastric ulcer is presented. A similar significance from a diagnostic and therapeutic standpoint may be attributed to the niche of a duodenal ulcer.

The author states: "Two difficulties arise. An irregular deformity of the duodenal bulb other than niche formation, which subsequently shows complete disappearance after medical treatment, may create the suspicion of having originally been due to spasm or possibly to incomplete filling. On the other hand, a persistent irregularity which remains unchanged in spite of complete clinical recovery over a long period of time does not necessarily mean that the ulcer has not healed. Unyielding scar tissue may be responsible for a deformity that remains permanently demonstrable in the radiogram. A more reliable criterion exists in the study of the changes in the niche of a duodenal ulcer, when this evidence is present. The disappearance of such a niche with clinical cure must be as acceptable as in the case of gastric ulcer."

Three case reports are given to illustrate the author's contention.

D. S. CHILDS, M.D.

The Duodenal Ulcer Crater. D. B. Harding. Southern Med. Jour., June, 1930, XXIII, 513.

The roentgen diagnosis of duodenal ulcer has become one of the most accurate diagnostic procedures available. This report is based on a study of 214 consecutive cases, in which a diagnosis of duodenal ulcer was made, and has special reference to ulcer craters. The author refers to the technic of Carman and Sutherland of compressing the duodenal bulb in the attempt to catch a fleck of barium in the ulcer crater. The demonstration of a duodenal fleck, when differentiated, justifies an unqualified diagnosis of duodenal ulcer, whether there is deformity of the bulb, or a definite niche is seen.

W. W. WATKINS, M.D.

GASTRO-INTESTINAL TRACT (THERAPY)

Peptic Ulcer: Etiology, History, and Surgical Treatment. Arthur Dean Bevan. Jour. Am. Med. Assn., June 28, 1930, XCIV, 2043.

Ulcer of the stomach was accurately described as a pathologic entity about a hundred years ago. Peptic ulcer is limited to the anatomic areas that are subjected to the action of gastric juice containing pepsin and free hydrochloric acid; *i.e.*, the stomach, the duodenal bulb, and the jejunum which has been anastomosed with the stomach as in gastro-jejunostomy, and in rare cases the lower end of the esophagus in close contact with the stomach. Peptic ulcer occurs in at least 10 to 12 per cent of the population. To master this subject one must master the anatomy, physiology, and pathology involved; the etiology and

diagnosis; the roentgenology, and both the medical and surgical treatment.

The duodenal bulb is not a part of the duodenum but a part of the stomach; its blood supply and innervation are the same as those of the stomach and not of the duodenum, and the mucous membrane is separated from the mucous membrane of the duodenum at the line of the sphincter of the duodenal bulb. More than 90 per cent of gastric ulcers occur along the lesser curvature from the esophagus to the pylorus. This is a vestigial structure representing a more complete partial tube in animals that chew their cud. Its mucous membrane differs from that of the rest of the stomach. Its blood vessels are more like end arteries than like those of the rest of the stomach. These anatomic facts favor the development of peptic ulcer in this area.

The essential causes of peptic ulcer are impairment of the vitality by injury, as disease of stomach mucosa and deeper layers to the point where they can be digested by the gastric juice. Lowering of the general resistance of the patient from any of a great number of factors is an added cause. There is little scientific evidence supporting the theory of focal infection from the tonsils or the teeth. Severe acute ulcers of the stomach may be of hematogenous origin, as a rule a part of a general infection.

It is probable that acute ulcers are frequent and that most of these heal spontaneously. The chronic ulcer is maintained by the irritation of the gastric juice, by traumas, and probably by low-grade inflammatory processes. Even the chronic ulcer in the majority of cases heals in time. The fact that peptic ulcer does heal and heals spontaneously must be accepted as a clinical fact. It should be possible by clinical, laboratory, and roentgenologic studies to make the correct anatomic and pathologic diagnosis in about 90 per cent of the cases.

Surgical management is demanded in cases of perforation, in cases in which massive hemorrhages have occurred, and in cases in which the possibility or probability of cancer exists. Deep penetrating and callous ulcers, difficult to heal under medical management, and cases in which cure cannot be effected by proper internal management should also have surgical intervention. The real problem in clinical work is the difficulty, at the time of operation, of making a positive diagnosis between a callous ulcer and a cancer of the stomach. Gastro-enterostomy has much to recommend it in surgical treatment of ulcer of the duodenum and stomach ulcers close to the pylorus. In callous ulcers of the stomach, resection is usually indicated. Partial pylorectomy has a definite place.

The field of peptic ulcer belongs to no one specialty. The general practitioner, the internist, the surgeon, the roentgenologist, and the pathologist are all concerned. Eighty per cent of the cases of peptic ulcer can be cured by good medical management. This is a field for good team work, and only where such team work has been developed can the ulcer patient receive the best that modern scientific medicine has to offer.

CHARLES G. SUTHERLAND, M.B. (TOR.).

GENITO-URINARY TRACT (DIAGNOSIS)

Diseases and Anomalies of the Ureters. R. A. McComb. Can. Med. Assn. Jour., April, 1930, XXII, 484.

The introduction of pyelo-ureterography has demonstrated that the ureter is frequently a potent factor in the causation of renal disease. Since the ureter is an aqueduct, and since the efflux of urine is produced by an intermittent muscular contraction starting in the pelvis of the kidney and ending at the ureteral orifice, it will readily be seen that any obstruction will increase the peristalsis, and tend to produce dilatation above the site of obstruction, extending into the kidney itself. The symptoms and end-results are the same, whatever the cause of the obstruction may be. They are pain, dilatation, infection, renal damage, and possibly calculus formation.

The most common conditions drawing our attention to the ureter are ureteral calculus and stricture. Ureteral stricture occurs chiefly at the uretero-pelvic junction, the brim of the

true pelvis, or the intra-mural portion of the ureter. The cause of its formation is believed to be largely inflammatory. Some cases are a legacy from the pyelitis of infancy and childhood: hence, the necessity for early recognition of stricture in connection with the persistent urinary conditions of childhood. Less frequent causes of ureteral obstruction are an aberrant vessel or a band of fascia, when associated with renal ptosis.

The anomalies of the ureter are briefly discussed by the writer. Ureteral disease is progressive and ultimately destroys the kidneys.

L. J. CARTER, M.D.

Ureteral Calculi: Based on Over Two Hundred Consecutive Cases in the Author's Service. Winfield Scott Pugh. Med. Jour. and Rec., June 4, 1930, CXXXI, 548, and June 18, 1930, CXXXI, 608.

Any case presenting the symptom-group of pain, hematuria, urgency, frequency, or any of these symptoms, calls for a complete urological examination. With such a picture, justice to the patient can be done only by cystourethroscopy, ureteral catheterization, renal function tests, and pyelography.

Seventy-six per cent of ureteral stones are in the lower ureter, but they may locate anywhere. About 80 per cent of ureteral stones will show clearly on a plain X-ray film, but it is often impossible by this simple examination to tell definitely whether or not they are in the ureter. Bransford Lewis' method is to have the stone shadow follow his dilator. The double exposure method, suggested by Ball in 1918, is used by the author. This consists in making two exposures on the same film, moving the tube between exposures. If a stone is in the ureter it will maintain the same relation to the catheter; if extra-ureteral, the shadow will show a difference in this relation in the two exposures.

(*Note:* The same information may be obtained by making stereoscopic films with a cross-shift of the tube. This has the added advantage of giving a stereoscopic roentgenogram for detailed study.)

W. W. WATKINS, M.D.

Pyelography Following Intravenous Injections. N. E. Berry. Can. Med. Assn. Jour., April, 1930, XXII, 546.

The members of the author's staff had noticed for a long time that the roentgenograms of the kidney, taken following the examination of the gall bladder by the Graham method, showed better defined kidney shadows than those obtained in the usual roentgenogram. It seemed, therefore, that some such intravenous injection might be of use as an additional aid in certain cases where an accurately defined kidney shadow is imperative, and that, incidentally, the renal pelvis might be visualized.

This idea was followed out in the Department of Urology of the Royal Victoria Hospital, Montreal. Sodium iodide was chosen as the opaque medium, both alone and in combination with other preparations. The experimental work was done on rabbits. It was found that a simple mixture of sodium iodide and urea was tolerated in enormous doses, provided the urea was in excess. It was found that with doses of two grams each of iodide and urea given to a rabbit weighing one kilo, the kidney pelvis could not be outlined, even with the ureter ligated, but that the bladder could be outlined with much smaller amounts, provided it did not contain more than 10 c.c. of fluid.

Experimental work is being done on a preparation for human use. The new method will be applicable only to the very difficult cases.

L. J. CARTER, M.D.

GYNECOLOGY AND OBSTETRICS

Pseudomyxoma Peritonæi Secondary to Ovarian Cystadenoma. James C. Masson and Robert A. Hamrick. Can. Med. Assn. Jour., April, 1930, XXII, 508.

This is a condition of the peritoneum in which masses of gelatinous, pseudomucinous or mucinous, material are distributed over the surface, either as a homogeneous layer, or in the form of multiple cystic masses. The cause of the condition is invasion of the peritoneum by material from a ruptured pseudomyxomatous cystadenoma of the ovary, or from a mu-

cocele of the appendix. The condition may be either benign or malignant. When the condition is benign, surgery will usually be sufficient, although a number of operations may be required. When the condition is malignant, the malignancy is usually of low grade. Both ovaries and tubes should be removed, with as much of the mucinous material as possible. As a rule, the uterus should also be removed. Extensive treatment with radium and X-rays should follow. A considerable extension of life and some cures may be expected.

L. J. CARTER, M.D.

Histologic Studies of the Uterine Mucosa after Radiologic Castration. Antonino Nicotra. Archivio di Radiologia, January-February, 1930, VI, 268.

The author examined histologically curettings from the uteri of three patients at the first or second menstrual period after "castration." The endometrium was normal in each case.

E. T. LEDDY, M.D.

Further Experience with Roentgen Abortion. M. Ganzoni and H. Widmer. Strahlentherapie, 1930, XXXVI, 510.

The authors report in this paper their experience with an additional 39 patients, abortion being induced by roentgen rays. The minimum dose effective in the uterus is about 300 r. From the tabulated case reports it appears that from 250 to 450 r, as measured on the cervix, were given. In three patients, the abortion started 152, 155, and 180 days, respectively, following irradiation.

E. A. POHLE, M.D., PH.D.

Radiographic Therapy of Sterility. Françillon Lobre. Brit. Med. Jour., March 29, 1930, No. 3612, p. 611.

Contra-indications to radiographic examination were the presence of active lesions, such as those accompanying metritis, salpingitis, appendicitis, or metrorrhagia. The best time for the exploration was the week following menstruation, from the fourth to the twelfth day. At this period adnexal reactions could be most effectively avoided; moreover, the risk of injection during pregnancy was eliminated by choosing a time shortly after menstruation had occurred. It was necessary to be sure that the cervical orifice was permeable, since radiographic examination was never to be immediately preceded by dilatation of the cervix. In order to ascertain whether the tubes were or were not permeable, a second radiogram had to be taken a few hours after the first to discover if the shadow still remained in the tubes, or was disseminated in patches in the abdominal cavity. For the purpose of this second examination the patient remained in the hospital or clinic a few hours before returning to her home. To avoid pain sodium bromide or benzyl benzoate was given for two or three days before the examination, and an analgesic suppository was introduced one and one-half hours before the examination, which was immediately preceded by swabbing the cervix with a solution of novocain.

The opaque substance used was 40 per cent lipiodol, rendered more liquid by warming on the water bath. It was well tolerated by the tubes. The pressure employed might be higher (up to 30 cm. of mercury) than was permissible when air was insufflated (in this case up to 23 cm. of mercury).

However highly the method might be perfected it would never constitute a specific treatment for sterility, since some forms are not mechanical in origin. The method confirmed and precisely demonstrated the clinical findings, and, likewise, supplied data giving rise to new medical and surgical methods of treatment.

For combating uterine or tubal spasm antispasmodic agents, such as belladonna, atropine, benzyl, or the bromides, might be used. If the tubes presented unduly small caliber, they might be first rendered permeable by injecting them with lipiodol, and their dilatation might then be attempted by repeating insufflation for a sufficient number of times.

Before undertaking operative measures designed to combat sterility, hysterography should be practised. Ligamentopexy, or stomatoplasty, should not be attempted without

assurance that the tubes are permeable. If permeability was not present, an attempt should be made to restore it. Twenty operations of this kind had been undertaken by the author, following advice based on radioscopic findings. Thus far the results had not been satisfactory, and in no case had pregnancy followed surgical treatment. Radiographic examination not only permitted etiological diagnosis, but often sufficed in itself to constitute the treatment of certain forms of sterility.

WALLACE D. MACKENZIE, M.D.

HEART AND VASCULAR SYSTEM (DIAGNOSIS)

Observations on the Clinical Value of the Roentgen Ray in the Diagnosis of Cardiovascular Disease. Paul D. White. Am. Jour. Roentgenol. and Rad. Ther., April, 1930, XXIII, 353.

The author presents several observations concerning the limitations of roentgenological study of cardiovascular disease, against which are balanced six reasons why this method of examination is worthy of routine application. The limitations are: (1) the method alone is quite incomplete and it ranks below careful history and physical examination; (2) it is least accurate in detecting the earliest stages of cardiovascular disease when laboratory confirmation is most needed for positive diagnosis; (3) certain serious and even fatal heart diseases may be present, such as coronary disease, and the roentgen findings may be entirely normal; (4) roentgenological studies while at first thought apparently to offer mathematical accuracy are in reality crude, because so largely dependent upon changes in size and shape, but slight changes due to early disease may not be distinguishable from variations within normal limits; (5) slight technical errors may result in most erroneous interpretations, hence clinical methods should be used to check the X-ray, just as the X-ray may be used to check clinical examinations; (6) the roentgenologist or internist making the X-ray examination should describe structural change only, and not attempt to make an etiological diagnosis; (7) the examination must be complete, including fluoroscopy in all positions.

The reasons for making the X-ray study as routinely as possible are: (1) skillfully applied, the method affords the most accurate measurements of the size and shape of the heart; (2) in the presence of obesity, emphysema or other condition making physical examination imperfect, the X-ray may be the only means of obtaining accurate measurements; (3) surprising and unexpected findings (for example, aortic aneurysms and pericardial calcification) may occasionally be demonstrated; (4) the size of the aorta and left auricle can be determined only by the X-ray; (5) hilum shadow changes and pulmonary artery abnormalities can be shown only by this means; (6) the roentgenoscopic observation of peculiarities of pulsation of the heart chambers and great vessels is alone worth the method of study.

J. E. HABBE, M.D.

A Standardization Roentgenologic Study of the Heart and Great Vessels in the Left Oblique View. George H. O'Kane, Fred D. Andrew, and Stafford L. Warren. Am. Jour. Roentgenol. and Rad. Ther., April, 1930, XXIII, 373.

The authors present a standard method for determining the relative size of the right and left ventricles. Area measurements on the left oblique postero-anterior view, with the right and left ventricles in profile, are said to be more accurate and to give a better index of cardiac volume than the postero-anterior view. The patient is routinely fluoroscoped first and the optimum angle (between 40° and 60°) determined for best visualizing the aorta and pulmonary vessels.

The technical factors are six-foot target-film distance, two-tenths second, 60 to 100 K.V., breath held in deep inspiration. Film measurements are made as follows: a base line is drawn from the notch between the right ventricle and aorta to the notch between the left ventricle and left auricle. The pulmonary

artery and aorta overlap each other at their bases about half of their respective diameters. A line erected perpendicular to the base line at the mid-point of this overlap will represent the interventricular septum, dividing the two ventricles. Lines are then drawn perpendicular to the last line to the borders of the right and left ventricles to determine their size. The diameters of the aorta, pulmonary artery, and aortic arch are also constructed. The heart area is computed on that portion of the heart shown below the base line, and, therefore, measures ventricle size only.

For simplification of comparison, hearts are grouped as normals, left ventricular and right ventricular preponderance, and generalized dilatation. A table of average measurements for these four groups is appended. Certain types of cases were found to show definite evidence of right ventricular preponderance on the oblique view, which the postero-anterior view failed to show.

J. E. HABBE, M.D.

Roentgenological and Pathological Findings in Some of the Valvular Lesions. David Steel, Am. Jour. Roentgenol. and Rad. Ther., April, 1930, XXIII, 384.

The author presents only those cases studied roentgenologically which were subsequently studied and checked by postmortem examination. Cardiac hypertrophy produces changes in the shape of the cardiac silhouette, while dilatation results in increase in size. The following signs are to be looked for in suspected enlargement of the left ventricle: (1) increase in the left median distance and horizontal diameter; (2) sharply defined junction between left auricular appendage and left ventricle; (3) absence of elevation of apex on deep inspiration; (4) elliptical to parabolic left lower arch; (5) change in ventricular pulsations; (6) an obliquely placed ovoid silhouette; (7) the bi-diaphragmatic angle remains inside the heart shadow, with the patient in the second oblique position, even on deep inspiration.

In aortic stenosis the predominating change is an hypertrophy of the left ventricle, with a bulging of the lower left arch, but without much increase in the left median distance. If dilatation also exists the cardiac apex will be spread. The roentgenoscopic findings are important. The pulsations are slow and forceful.

In aortic insufficiency there is a marked increase in the left median distance because dilatation overshadows the hypertrophy. The left lower arch becomes rounded and the great vessels appear to ride on the horizontal portion, producing a "duck-shaped" or "shoe-shaped" heart. Pulsations increase rapidly. The aortic shadow is dense and dilated in all diameters.

The findings in mitral lesions have been previously described in detail by the author.

In combined mitral and aortic lesions, the cardiac silhouettes are intermediary and depend upon the predominating lesion. Superimposed upon the monotonous upright silhouette of a mitral lesion are the changes produced by the aortic lesion, with associated insufficiency. The heart is partially oblique and presents a "stair-step" left border. With aortic stenosis complicating a mitral heart, the aortic lesion may be best detected by the character of the pulsations.

J. E. HABBE, M.D.

Some New Critical and Experimental Contributions to the Clinical Study of the Volume of the Heart. Giovanni Giordano. Rivista di Radiologia e Fisica Medica, January, 1930, II, 26.

The author describes some studies on the volume of the heart made according to the methods of Brugsch, Geigel, Salotti, and Cignolini, in which the orthodiagraphic method was used as the basis of calculation. As test objects, radioplastic nodes, according to the method of Palmieri, were used. Giordano believes that the mathematical method of Salotti is less subject to error than the others and is, therefore, the most valuable method to use in large-scale researches, particularly since it is very simple to carry out.

E. T. LEDDY, M.D.

LIGHT THERAPY

Specificity of Light Action in Tuberculosis. Winthrop M. Phelps. Jour. Bone and Joint Surg., April, 1930, XII, 253.

The outdoor sunshine of the Alps, the sea shore, and even of smoky sea-level cities can be used to advantage in the general treatment of tuberculosis, but sunshine filtered through window glass is practically valueless. Smoky sea-level air transmits practically no radiation shorter than 3,200 Å., and window glass transmits only feebly radiation shorter than 3,800 Å., so the radiation useful in tuberculosis must lie between these two points in the (invisible) ultra-violet region of the electromagnetic spectrum.

Phelps records thirty-four cases of tuberculosis of glands, bone, peritoneum and other tissues treated with sunshine in the sea-level manufacturing town of New Haven. Most of the patients were children from six months to fourteen years of age and the period of treatment varied from six weeks to three years. In most instances results were considered good. Sinuses healed and function was improved. It is felt that possibly the effect is general for chronic wounds and not specific for tuberculosis.

Dosage was controlled by a radiometer on the roof of the hospital connected to a recording device inside the building. Readings were in units of gram calories per square centimeter of body surface per minute, and the empiric dose was 90 units front and 90 units back daily. This required exposure times varying from 55 minutes front, 55 minutes back, to two hours front and two hours back, depending on the weather. On cloudy days exposure throughout the day did not deliver the desired dose, and to meet this difficulty, as well as the problem of exposure on severe winter days, artificial radiation was required.

"Pan-Ray-Arc" lamps were used, equipped with aluminum reflectors and 13 millimeter diameter "Sunshine Carbons." Working at 30 amperes (voltage not stated), the intensity at one meter distance was approximately one gram calorie per square centimeter per minute.

The spectrum of the lamp was rich in the desired wave lengths (3,200 to 3,800 Å.), but included also shorter radiation (for instance, the ultra-violet 3,000 to 3,130 Å. specific for rickets) and much of the visible spectrum (4,000 to 8,000 Å.).

Patients received unfiltered radiation, but a few animal experiments suggest that it may be advantageous to filter the beam with Corning glass filter No. G986A, which removes most of the radiation shorter than 3,200 Å. and longer than 3,800 Å., thus avoiding the excessive tanning and erythema so characteristic of radiation between 3,000 and 3,200 Ångström units.

PAUL C. HODGES, M.D.

Carbon Arc Light Treatment in Bone and Joint Tuberculosis: Observations on the Methods and Immediate Results of Treatment with the High Intensity Carbon Arc Light in Tuberculosis of the Bones and Joints. Katharine Pardee. Jour. Bone and Joint Surg., April, 1930, XII, 270.

The winter climate in Baltimore is not satisfactory for the treatment of surgical tuberculosis, and the Children's Hospital School finds it necessary to use artificial radiation for almost six months of the year. Quartz mercury lamps have been tried in previous years without success (no information as to current, filter, exposure time), but a new carbon arc lamp operating at 90 amperes is considered of definite value.

The illustrations suggest that the "lamp" is really several carbon arc burners, so there is some question as to whether the current stated is for one burner or for a group. The distance from arc to patient appears to be approximately 10 feet, and the exposure time is 15 minutes front and 15 minutes back daily.

Twenty-two children treated throughout the winter show in most instances gain in weight, increased red blood cell count, improvement in general bodily condition, and improvement in the X-ray appearance of the bone lesions.

PAUL C. HODGES, M.D.

NERVOUS SYSTEM (GENERAL)

The Direct and Indirect Action of X-rays on the Suprarenals. II.—The Variations in

Blood Sugar. Quintino Vischia. Rivista di Radiologia e Fisica Medica, January, 1930, II, 71.

Experiments carried out by the author in which the suprarenals of dogs and rabbits were irradiated showed that a hyperglycemia is produced. It begins immediately after irradiation and lasts several hours. The author discusses various explanations for this finding, and concludes that irradiation of the suprarenals had a definite effect on the vegetative and especially on the sympathetic nervous system.

E. T. LEDDY, M.D.

The Capillary Changes Produced by X-rays. Luigi Turano. Archivio di Radiologia, March-April, 1930, VI, 349.

The author demonstrates the peculiar differences between a normal capillary microscopic field and a pathologic one, and points out how the changes produced by X-rays may be followed by the capillary microscope, enabling one to prognosticate the radiosensitivity of the case in point by observation and study of the changes in the capillaries, which may be dilated or constricted. He regards these alterations as manifestations of changes in the balance of the vegetative nervous system.

E. T. LEDDY, M.D.

The Effect of X-rays on Microglia. Desiderio Perotti. Rivista di Radiologia e Fisica Medica, March, 1930, II, 171.

After a short review of the nature and function of microglia, the author describes some experiments which he carried out on the effect of X-rays on the reticulo-endothelium of the central nervous system, to which the microglia belong. He treated the brains of rabbits and dogs with increasing doses of X-ray, and killed the animals at various periods after the exposures. He found that the microglia are the most sensitive element in the central nervous system, and that their sensitivity was even greater than that of the endothelium of the blood vessels. He concludes that the great sensitivity of the microglia is due to the function of defense of these microglia as part of the recticulo-endothelial system, and that these cells are less differentiated than others in the nervous system.

E. T. LEDDY, M.D.

RADIUM

Radium Treament of Cancer (Cancer of the Skin: Measurement of Radium Dosage). John Murdoch. Brit. Med. Jour., May 17, 1930, No. 3619, p. 911.

Cancer of the Skin.—In cancer of the skin the superiority of radium over X-ray therapy has been demonstrated, though it is not yet clear whether this is due to the shorter wave length of the gamma rays or to the fact that radium was continuously applied. According to recent research in Brussels it seems probable that in order to produce the same amount of biological action, such as an erythema dose in the case of the skin, it is necessary to apply to the tissues a much larger amount of energy in the form of gamma rays than in the form of X-rays. The proportion is about four to one.

Cancer of the skin is never too large or too advanced for radium therapy.

In cancer of the tongue, the condition most willingly handed over by the surgeon to the radiotherapist, even a slight improvement on the surgical results is a great boon to the patient. Yet, cancer of the tongue is not a radiosensitive variety and the radiosensitivity of the glandular metastases is even less than that of the primary lesion. Owing to the bad results obtained by deep X-ray therapy, preference is given to local radium treatment.

Cancer of the cervix uteri was one of the first cancers to be successfully treated by radium, the good results being primarily due to the anatomy of the parts. X-ray methods have also reached in this condition a high degree of perfection, and, far from being opposed to each other, the two methods are probably destined more and more to be used together. Radium therapy of the cervix uteri appears to have a slight advantage over surgery.

The introduction of radium into the lumen of the esophagus has proved a failure.

Radium in cancer of the rectum gives similarly disappointing results, but the ingenious method of Neuman and Coryn of interstitial needling is used in inoperable cases and sometimes results in making a case operable.

Measurement of Radium Dosage.—The various units of radium absorption which have been put forward from time to time are discussed, and reasons given why in Belgium the ingenious method brought out by Stahel in 1928 has been adopted. This is expressed in ergs per cubic centimeter for the amount of radium energy absorbed. Many slides were shown by the speaker (the paper was presented originally in the form of a lecture), illustrating the disposal of the radium tubes so as to secure homogeneous radiation, tables were given for the distribution of the energy, and an explanation of his method of interstitial radiation by means of needles laid parallel, as nearly as possible, in the tissues. The limitations of the "bomb" method as compared with the interstitial method for securing intense action on the growth were discussed.

WALLACE D. MACKENZIE, M.D.

Retrograde Needling: A New Technic for Inserting Radium Needles in Carcinoma of the Tongue. K. H. Pridie. Brit. Med. Jour., March 1, 1930, No. 3608, p. 380.

This method was devised to hold the radium needles in place in spite of the mobility of the tongue and the movements incident to deglutition, when the growth is in the epiglottic region and the base of the tongue is infiltrated.

The radium needles to be used are threaded on a long length of Pagenstacher No. 2 and knotted once over the eye. The tongue is drawn forward and a Greig-Smith abdominal needle is introduced into the space between the hyoid bone and the mandible; a finger introduced into the mouth guides the needle so that it comes out through the margin of the growth into the mouth. One end of the thread attached to the radium needle is then threaded through the Greig-Smith needle, which is withdrawn through the skin of the neck, and detached. By pulling on this thread the radium needle is drawn backwards into the growth till the point just disappears. A small piece of rubber tube is threaded on the end where it comes out of the skin, to indicate the depth of the needle in the growth. A piece of rubber tubing is threaded on to the other end to protect the lip, and both ends are knotted together loosely, forming a complete loop. In a similar manner, other needles are placed all around the growth.

By pulling the threads the needles can be made to travel either down into the deeper parts of the tongue and glands and finally out through the skin in the submaxillary triangle, or up into the mouth.

WALLACE D. MACKENZIE, M.D.

Radium Treatment of Cancer of Rectum. Sir Charles Gordon-Watson. Brit. Med. Jour., May 24, 1930, No. 3620, p. 951.

In 1927, the author regarded a preliminary colostomy as an essential part of radium treatment of rectal carcinoma, but since then has treated a number of cases without colostomy, with equally good results. The greatest obstacle to efficient radiation is difficulty of access. The strongest argument that can be urged for radium in a case considered suitable for radical surgery, on both local and general grounds, is a reasonable prospect of destruction of the growth, with restoration of rectal function, and without expectation of recurrence.

In the treatment of inoperable cases there is a marked improvement both in the general and local conditions, in cases treated by colostomy and radiation. It is further demonstrated that, even in cases which had been submitted to colostomy some months previous to radiation, rapid marked general improvement followed radiation, though local changes might be absent.

Borderline cases offer an even more useful field for radiation, either as a forerunner of excision, or, in some instances, with prospects of cure without excision—some of these (high rectal growths) are treated by radiation through an abdominal incision. Radium has a further valuable field in the early treatment of local recurrence after excision.

It is concluded that, while at present surgery holds first place, it is reasonable to anticipate that radium may become the method of choice in the near future.

W. D. MACKENZIE, M.D.

ROENTGEN THERAPY

Anemia, Age of Cell, and Susceptibility to Radiation. Otto Dyes. Strahlentherapie, 1930, XXXVI, 552.

The author epilated the scalp in a number of patients by using a cone attached to the tube holder. On those spots where the cone pressed on the scalp, thus rendering it anemic, the hair did not fall out as in the remaining part of the field, following the application of 640 r. This remaining hair fell out several months later, but only very gradually. He concludes from this observation that the epilation dose for anemic skin is much higher than for normal skin. A similar difference in susceptibility was seen between the hair irradiated for the first time and the regrown hair. If four months after the first application of 640 r the same dose was repeated, delayed epilation occurred.

E. A. POHLE, M.D., PH.D.

The Roentgen Treatment of the Lymphatic Tissue in the Pharynx during Childhood. Herbert Schönfeld and Gottfried Baumbach. Strahlentherapie, 1930, XXXVI, 472.

During the past three years the authors have treated with roentgen rays 150 children ranging from 3 to 13 years of age, who were suffering from hyperplasia of the tonsils. Technic: 180 K.V., 0.5 mm. copper + 1 mm. Al, half value layer in copper = 0.9 mm., 6 × 8 sq. cm. field on each side of the neck. The dose in the lymphatic tissue amounted to about 180 to 300 r. The treatment was sometimes repeated four weeks after the first exposure and, if necessary, eight weeks after the second. More than three treatments were not given. One hundred and six cases could be followed up; in 57 per cent the tonsils reduced often to normal size, while in 43 per cent no change in size occurred. From two to three years after X-ray treatment the tonsils had remained small in only 47 per cent, which means a recurrence of 28 per cent. The relief of the symptoms accompanying the tonsil hypertrophy, as, for instance, sleeping with open mouth, snoring, frequent infections of the throat, was definite in all cases which had responded to treatment. No chronic changes in the mucous membranes or glands due to the irradiation were observed. It is concluded that X-ray therapy of hypertrophic tonsils is chiefly indicated in children subject to frequent infections of the nose and throat.

E. A. POHLE, M.D., PH.D.

Roentgenotherapy of Diseases of the Hematopoietic System. Eugenio Milani. Archivio di Radiologia, March-April, 1930, VI, 379.

This is an excellent and succinct review of what is known about the radiotherapy of diseases of the blood-forming system.

E. T. LEDDY, M.D.

Principles of Roentgenotherapy. V.—The X-ray Laboratory: General Treatment Technic. Ernst A. Pohle. Wisconsin Med. Jour., May, 1930, XXIX, 268.

This is the fifth paper of a series on this subject, and deals briefly with the equipment necessary for therapy and the protection of the operator and the patient. The author discusses the four principal methods of administering X-ray therapy: (1) the single massive dose; (2) the fractional dose; (3) the saturation method; (4) the prolonged exposure.

The importance of keeping detailed records and of standardization in treatment are also discussed in this paper.

W. W. WATKINS, M.D.

Our Experience with Spleen Irradiation in Chronic Myelogenous Leukemias. A. Rikl. Med. Klin., June 13, 1930, XXVI, 891.

The author reports his success with spleen irradiation in thirty-one cases of chronic myelogenous leukemia. The treatment factors were: 165 K.V., 4 ma., 40 cm. distance, and a

filter of 0.5 mm. Zn and 1 mm. Al. The time of exposure was varied according to individual indications. Many of the patients acquired a refractory state after repeated irradiation, evident in the blood picture as well as in the behavior of the splenic tumor. In six of these patients the disease could finally not be influenced at all, and the terminal picture of increasing cachexia, intermittent fever, and a hemorrhagic diathesis did not yield to any amount of irradiation. At the beginning of the roentgen therapy in these thirty-one cases, no refractory state had been observed to exist. The final failure of irradiation therapy shows that we are treating only a symptom of the disease and that we do not as yet have the causative factor for it. However, roentgen therapy of myelogenous leukemia is held to have its indication and its value.

H. W. HEFKE, M.D.

SKIN (THERAPY)

Blastomycosis of the Eye. S. Hanford McKee. Can. Med. Assn. Jour., April, 1930, XXII, 501.

Blastomycosis, or blastomycetic dermatitis, is a chronic disease of the skin caused by a fungus, and frequently involves the eyelids. The writer goes into the etiology, pathology, and diagnosis of the condition. The treatment may be summed up in two measures: the administration of heroic doses of iodide of potassium, and the use of the roentgen rays.

L. J. CARTER, M.D.

Radiotherapy in Dermatology. R. H. Stevens. Illinois Med. Jour., May, 1930, LVII, 336.

The author makes a strong plea for a better understanding of the physical agents used in radiotherapy, and pleads for a closer co-operation between the radiotherapist and dermatologist. He discusses in detail, facts and theories of skin structure and function, stressing the probable biologic effects of radiation.

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An abstract cannot do justice to this excellent paper.

C. H. DEWITT, M.D.

On the General Body Exposure with Bucky's Borderline Rays in Skin Diseases. Herbert Fuhs and Josef Konrad. Strahlentherapie, 1930, XXXVI, 520.

The authors have studied the effect of general body exposures to roentgen rays of long wave length (1 to 2 Å.) in 104 patients suffering from twenty-one different skin diseases, and have come to the following conclusions. In variance with the observations of Bucky, Spiethoff and others, no definite therapeutic effect on skin diseases could be observed from general body exposure to borderline rays. It is possible, however, that with the improvement of apparatus and technic this preliminary impression may have to be revised.

E. A. POHLE, M.D., PH.D.

TUBERCULOSIS (DIAGNOSIS)

Tuberculosis of the Symphysis Pubis. Harold C. Bean. Jour. Bone and Joint Surg., April, 1930, XII, 345.

The author reviews the literature on this subject and adds one case. A young woman twenty-three years of age had suffered from low back pain and limping for two years, unrelieved by sacro-iliac belts and pelvic surgery. Finally pain at the symphysis appeared, and X-rays showed destruction of bone. A diagnosis of osteitis fibrosa cystica was made, sequestrectomy and bone graft ankylosis were done, and biopsy showed tuberculosis. There was complete relief from symptoms.

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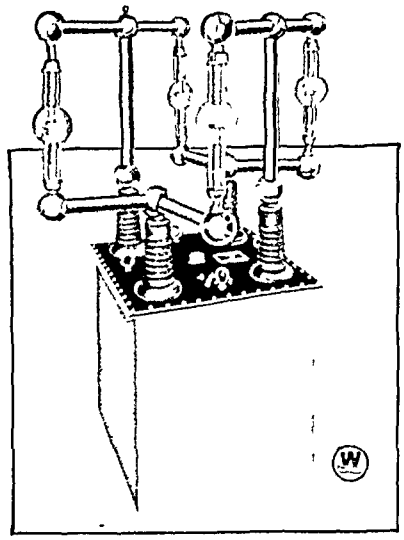
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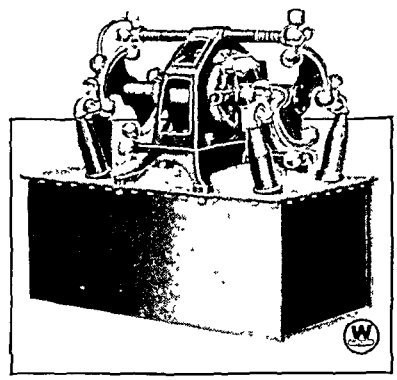
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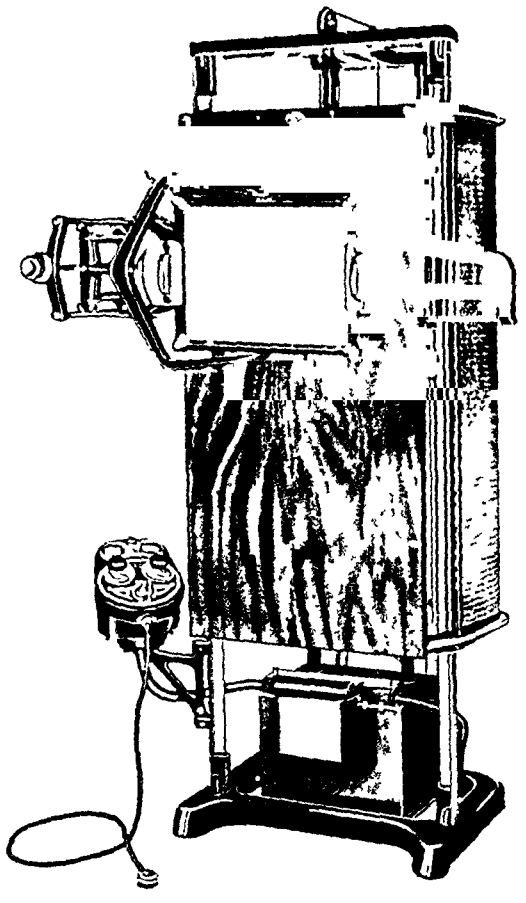
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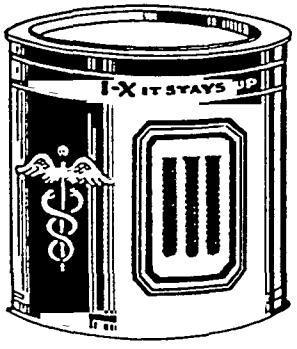
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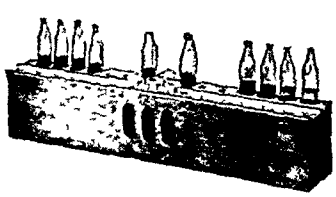
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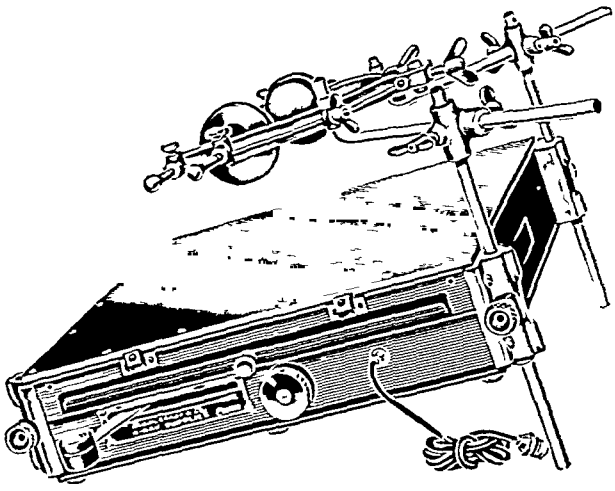
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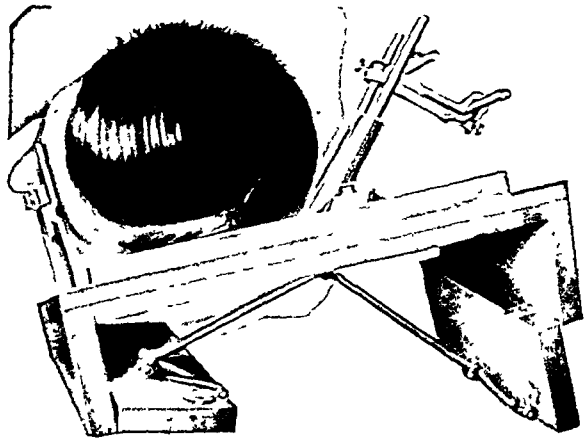
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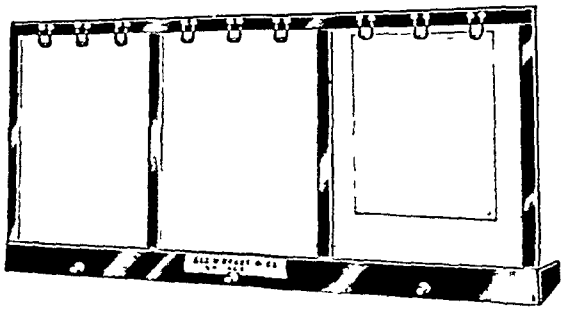
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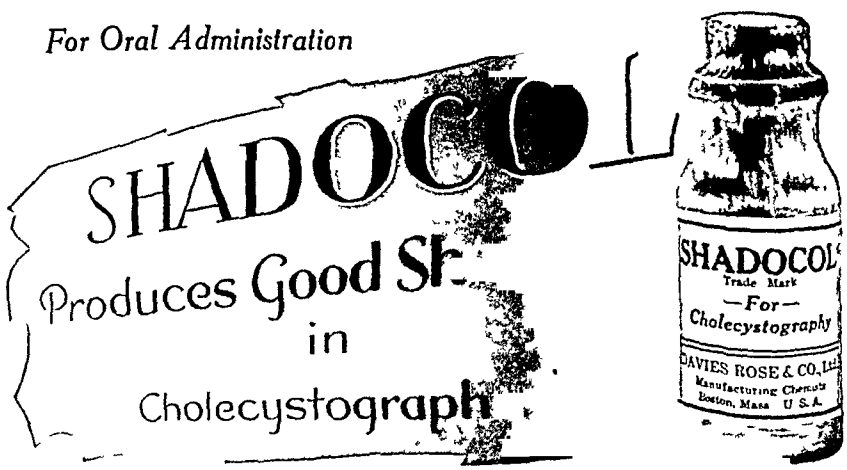
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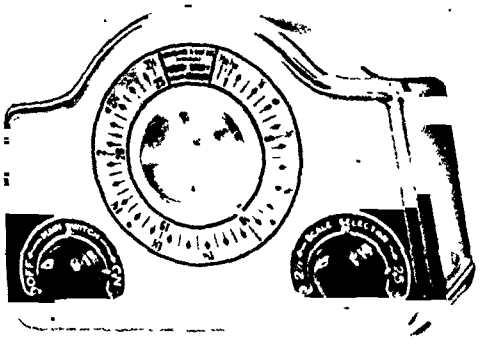
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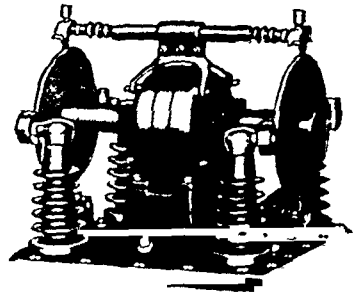
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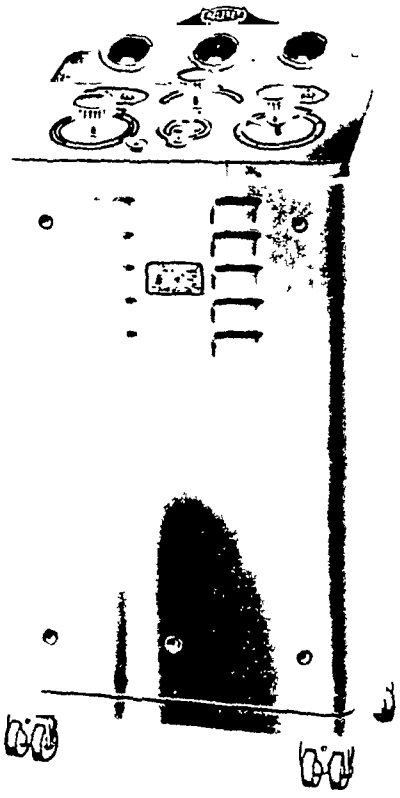
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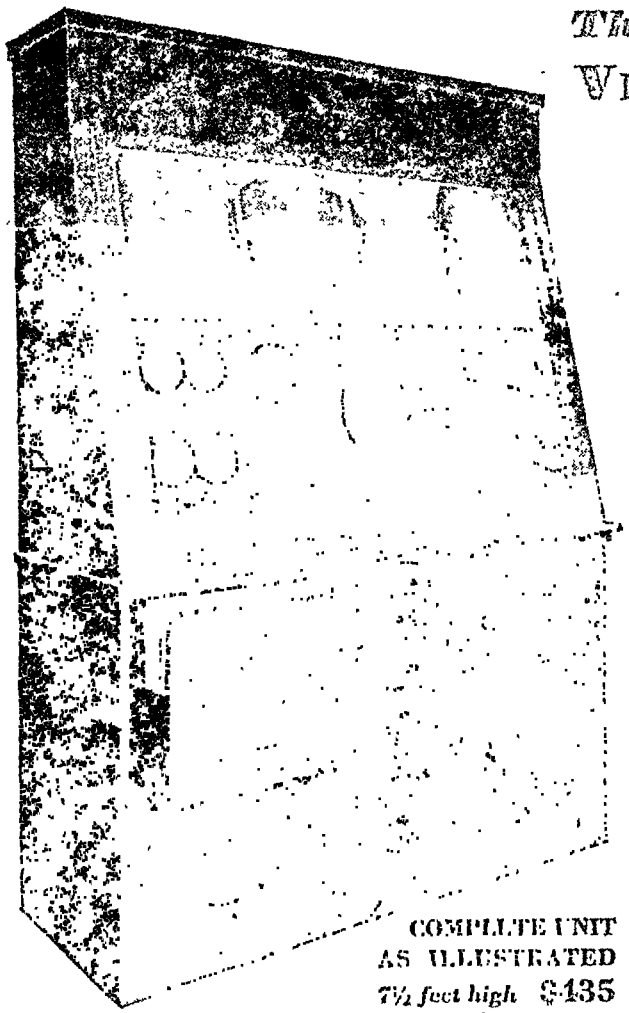
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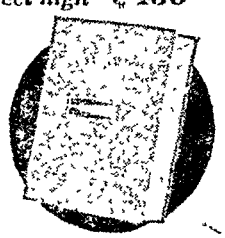
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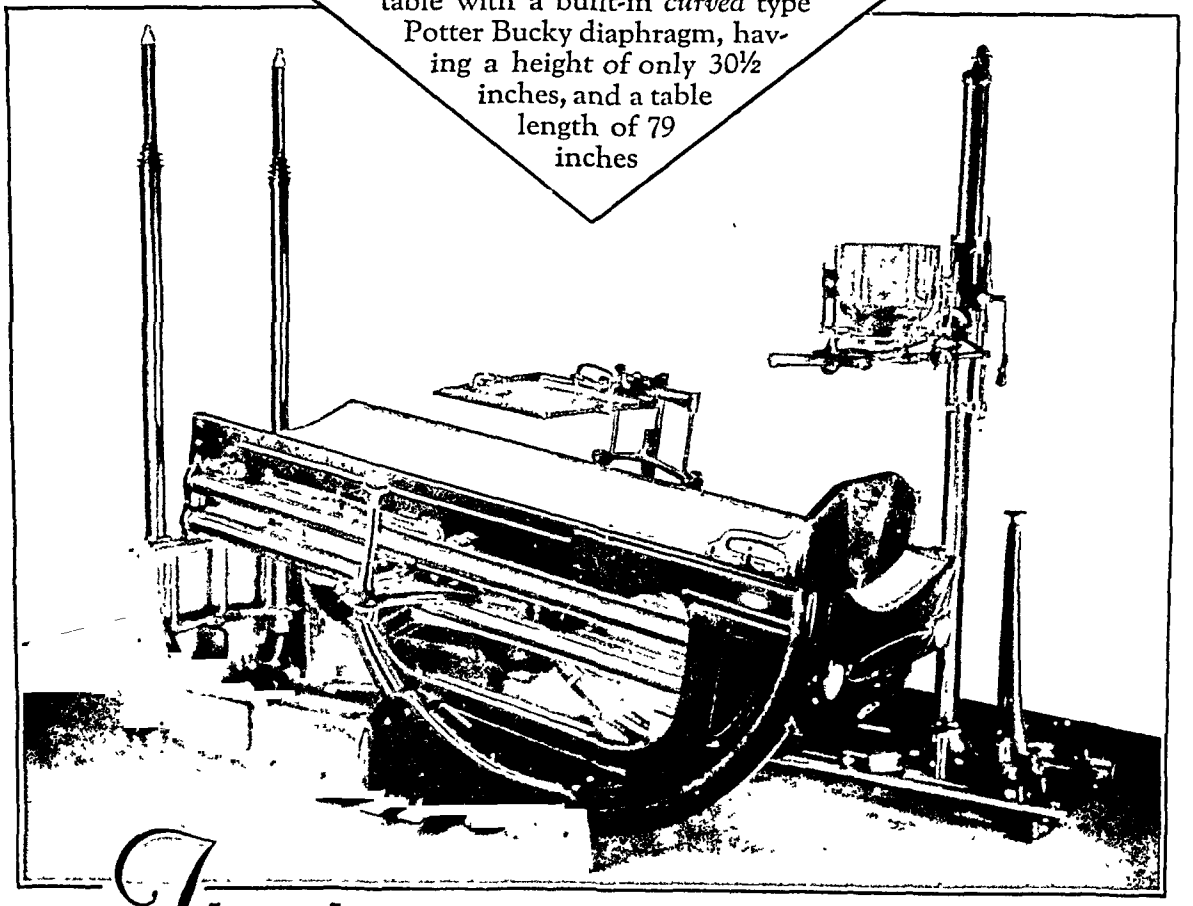
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PUBLISHED BY THE RADIOLOGICAL SOCIETY OF NORTH AMERICA

VOL. XV AUGUST, 1930 No. 2

ENCEPHALOGRAPHY AS THE ROENTGENOLOGIST SHOULD UNDERSTAND IT

AN ATTEMPT TO STANDARDIZE THE PROCEDURE[1]

By HENRY K. PANCOAST, M.D., and TEMPLE FAY, M.D., PHILADELPHIA

From the Department of Roentgenology and Neurology, University of Pennsylvania, and the Department of Neurosurgery, Temple University, Philadelphia

ENCEPHALOGRAPHY has become established as a valuable and reliable roentgenological procedure for the more exact diagnosis and localization in cases presenting symptoms of organic cerebral pathology which are more or less obscure. Roentgenologists are by this time fully cognizant of the difference between the procedures of encephalography and ventriculography. By means of the former we are now able to detect many cortical lesions that never could be diagnosed before the procedure was instituted, and varying in degree from their very incipiency to the most aggravated forms.

It is now possible by proper technic to obtain a clear visualization of the cerebral surfaces surrounded by cerebrospinal fluid. The outline of the fluid spaces when filled with air, as shown on the roentgenogram, is such that one familiar with the structures and neuro-anatomy can determine even slight disturbance in the relationships existing in various areas of the brain. By comparing the abnormal appearances of the fluid spaces with pathological specimens showing similar gross defects, or from verified operative findings following encephalography, it is now possible to interpret and diagnose correctly the major portion of these cases from a study of the roentgenograms, after due consideration of the history and neurological findings.

All accurate roentgenological diagnosis must be based upon a thorough knowledge of the anatomy of the part examined, a comprehensive understanding of the pathological changes in the conditions amenable to diagnosis, familiarity with normal radiographic appearances, and experience in interpretation.

Encephalography deals with a comparatively new field for the roentgenologist. His knowledge of brain anatomy has been largely forgotten. He is unfamiliar with cerebral neuropathology. As a result of these temporary shortcomings he cannot cooperate with the neurologist or neurological surgeon in the same way that he does in the elaboration of the most accurate diagnosis of conditions involving other parts of the body, as the chest and abdomen. Hence accurate encephalography has not been making the rapid strides it should have made. The roentgenologist in very many instances has been relegated to the position of a techni-

[1]Presented before the Fifteenth Annual Meeting of the Radiological Society of North America, Dec. 5, 1929, Toronto, Canada.

cian, without the proper guiding mind and hand to direct him along such lines as to develop the best technic. As a result there is dom of exact standardization, especially when they are the ones most vitally interested in the need of precision and accuracy.



Fig. 1. Encephalographic chair devised for this procedure in place beside the vertical Bucky with fixed tube stand, preparatory to encephalography.

at present—or has been until quite lately—a total lack of standardization of the roentgenological technic in encephalography. It seems strange that many neurologists and neurological surgeons do not realize the wis- These requirements must be based upon the intensive interest of the roentgenologist, and surely technical work has very little interest for him. The highest development of this part of roentgenological diagnosis will be at-

tained only after his interest is fully aroused. It is only by a mutual understanding between us as roentgenologists and neurologists or neurosurgeons that any degree of perfection has been reached in obtaining perfectly satisfactory roentgenograms capable of proper interpretations. The mutual understanding of each other's problems has been productive of the best results.

As an example of the lack of co-operation, during a recent visit to a large and well known institution we were told by a neurological surgeon that he always made his own interpretations and that he did not believe this to be within the province of the roentgenologist. We were then asked to interpret some supposed encephalograms. Noticing some unusual peculiarities in their appearance we inquired as to how they were made and were rather startled to learn that the exposures were all being made with the patient in the horizontal position. These were, of course, not encephalograms at all, and represented the most flagrant violations of technic, and yet a neurological surgeon was attempting to make absolutely impossible interpretations from them.

Standardization of technic is of the utmost importance—this applies to both the surgical and the roentgenological procedures. Each should be carried out in a careful and exact manner in all essential details and should be capable of exact duplication in all cases. There are three important reasons for this: (1) All neurological surgeons and roentgenologists should be able to talk in the same language and be able to make interpretations of the roentgenograms of another group when supplied with the necessary clinical data; (2) it should be possible to make comparisons of the various stages of a progressive lesion at different periods; (3) in examining a group of individuals with the same or similar lesions, it should be possible to compare one with the other or to compile accurate data or collect valuable information. For these reasons we are making a plea for the standardization of technic among roentgenologists, and we are also offering them suggestions for the furtherance of a better understanding of the whole procedure of encephalography, to enable them to make correct interpretations.

(A) ROENTGENOLOGICAL TECHNIC

The essential features of the technic are technically perfect roentgenograms, just as in the chest or elsewhere in the body, and made in the vertical position. No conscientious roentgenologist will attempt to base a diagnosis upon mediocre or faulty roentgenograms of the chest. Technically perfect roentgenograms imply a correct technic on the part of both the roentgenologist and the neurological surgeon or neurologist making the air injection. Sufficient air must be admitted and properly distributed to enable any one to make correct interpretations. Insufficient air or failure to manipulate the patient for its proper distribution cannot do otherwise than lead to faulty interpretations. For example, in the absence of obstruction in the ventricular system, all of the ventricles should contain air. Failure of the ventricles to fill must be regarded as implying faulty operative technic unless it can be satisfactorily proven that some good reason exists for the exclusion of air or the emptying of fluid from the system. The same remarks apply to the filling of one lateral ventricle without midline shift.

Proper roentgenological technic should produce clear roentgenograms of the best possible detail in order to show the finer cortical air markings clearly, by contrast with surrounding brain structures. The first essential feature in the production of such roentgenograms is the use of the Bucky diaphragm. Encephalograms made without the use of this device will not answer our purposes. Various devices may be used so long as they embody the correct principles. The apparatus we have been using for the

past two or three years has been described by Pendergrass (25) 1927, (26) 1928, and by us (24) 1929. It has proved very satisfactory and is as safe as it can be made. A specially made reversible flat Bucky, originally intended for ventriculography, is suspended on an old stereoscopic chest shift, and can, therefore, be placed at any height to suit the patient. On the front are drawn two lines crossing the center at right-angles for purposes of properly placing the patient's head.



Fig. 2. The position of the patient for anteroposterior view with the Bucky tilted forward, the head of the patient fixed, plate changer and the body in position for this exposure. Note that the height of the chair permits change of position of the patient without disturbing the height of the Bucky diaphragm. The Bucky magnetic shift is operated from the transformer control.

The patient is brought into the examining room sitting up in a chair especially made

for this purpose, and in which the surgical part of the procedure has been performed (Fig. 1). This chair is simple in construction but should meet the following requirements: (1) Easy access to the spinal canal with the patient in the sitting position; (2) support for the patient so that the sitting position is maintained at all times during the air injection and throughout the transportation to the roentgenological laboratory as well as during the period of making the exposures; (3) rapid mobility of the chair by means of large castors so that ease of transportation as well as rapid changes of posi-



Fig 3 Position of the head for lateral stereoscopic roentgenograms in encephalography The patient must be maintained in the erect position throughout the entire examination

tion during the roentgenological procedure may be accomplished.

As the initial pressure of the cerebrospinal fluid is always taken with the patient in the horizontal position before undertaking the air injection, the patient is transferred to the chair and placed in the upright position after this determination has been made. The air injection is always made in the sitting position.

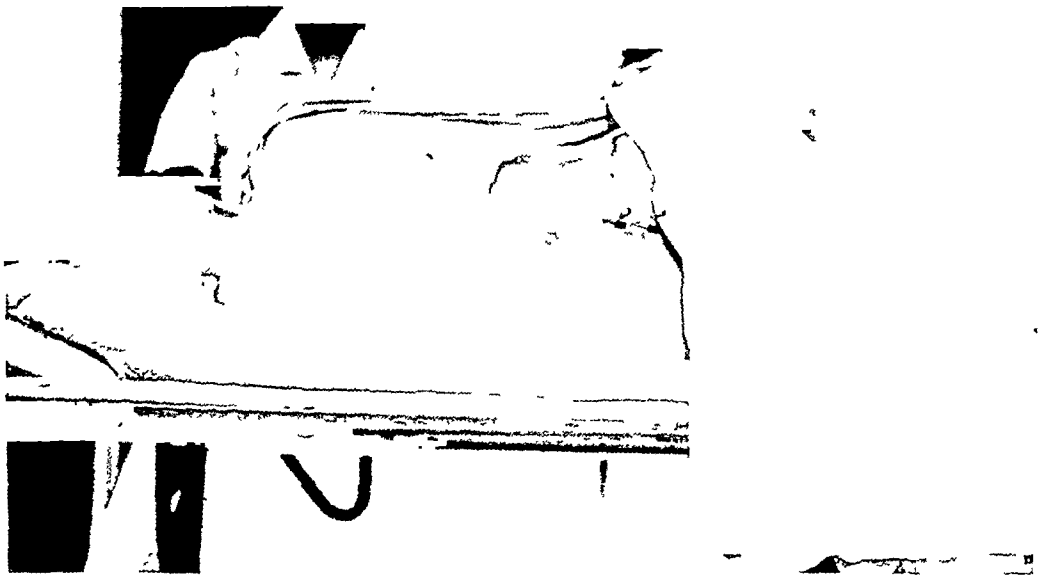


Fig 4. Patient in horizontal position, preparatory to encephalography. Note two spinal needles in place Initial pressure reading is always made in this position.

Although we have found such a chair a distinct convenience, in its absence the use of a litter will permit both the horizontal and sitting positions, the patient being transferred to a wheel chair and then again to the roentgenologist's stool. Movements of the patient necessary after each exposure being awkward under these conditions, the chair devised for this procedure has greatly simplified the handling of such cases. The use of such a chair implies that the distance between the tube stand and Bucky support must be ample to accommodate the chair and permit of its being turned around for the various views necessary As encephalographic procedures are uncertain as to time, but the roentgenographic part of the work must be carried out as soon as the patient is brought to us, it behooves us to have our roentgenological equipment always in readiness, otherwise valuable time will be lost and the usual routine schedule of the department very much disturbed. For these reasons all that we have to do is to wheel the patient in front of our regular chest shift and suspend the Bucky upon it. The tube stand and tube are always in position for chest roentgenography at a target film distance of 48 inches: the suspended Bucky has brought this distance down to 44 inches (Fig. 1). This distance has the further advantages of eliminating distortions and adding to the clearness of detail.

Recently, because of the installation of a new chest shift, we have moved the old one and a tube stand into a separate small room where it is operated by its own transformer unit, the same target film distance being maintained. This obviates still further the necessity of disturbing the regular routine

work. Naturally the equipment for all of the roentgenographic procedure should be easily accessible to the room in which the

in order, later, to be able to determine whether or not there is any midline shift of the brain structure, ventricles, or hemi-



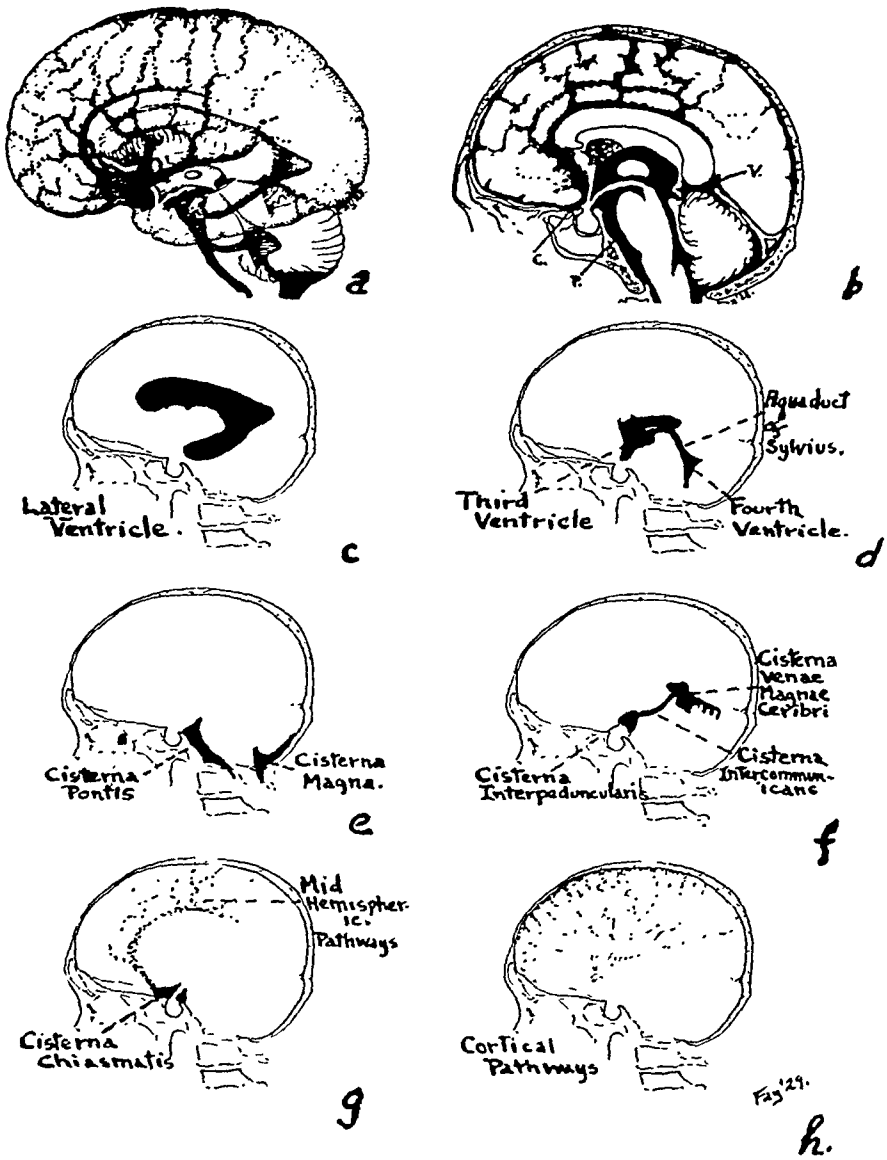
Fig. 5. Patient in the sitting position, with upper needle connected to a manometer and lower needle used for drainage of spinal fluid and the introduction of air. Care is taken never to permit intracranial pressure to rise above 20 mm. Hg.

operative technic is carried out. One man and nurse are trained to do all of the roentgenographic work and they can handle patients easily and also without disturbing the regular schedule. When the patient arrives he is wheeled on the chair in front of the suspended Bucky into position for the first or postero-anterior view. There is plenty of clearance for his legs and all parts of the chair under the cassette shift. His head is so placed that the midline of the forehead is in contact with the central line drawn on the Bucky. A long pointer from the tube holder, pointing at the midline of the back of the head, can be used to fix the head in an exact sagittal plane, but this becomes unnecessary with practice. A muslin restraining band is now applied to hold the head in this position, great care being required in placing the patient's head because it is absolutely essential that the central ray shall pass accurately through the mid-sagittal plane of the head

spheres. The head must be tilted forward in order that the lateral and third ventricles may be projected well above the frontal sinuses. This view gives clear definition to the anterior horns, third ventricle, and cortical air markings, especially those over the frontal lobes. The exposure factors we have found necessary for this view at 44 inches distance are 240 milliampere-seconds, with a six- to seven-inch spark gap. If stereoscopic films are desired, the tube shift must be five inches at this distance, and the shift should be vertical in order that flat film readings may be made from either roentgenogram. We have not found stereoscopy routinely necessary in this view. When stereoscopic exposures are made it is necessary with our equipment to change the cassettes by hand instead of by an automatic shift.

The patient's head is then released and the chair turned around for the posterior view,

to show especially the posterior horns of the lateral ventricles, and also the cortical air markings. The same care is required in placing the head correctly as for the anterior view. It is well fixed and the restraining band is placed over the chin to hold it so, in order, again, that the lateral and third ventricles may be projected clear of the upper accessory nasal sinuses (Fig. 2). The exposure factors are the same as for the anterior view, although stereoscopic roentgenograms are here important.



Figs. 6-*A* to 6-*H*. Diagrammatic representations of the cerebrospinal fluid pathways and spaces, showing sagittal sections with a key to the principal cisternæ usually visualized on the roentgenogram. Obstruction to the passage of fluid along any of these pathways produces dilatation behind the point of obstruction and failure to fill the distal channels.

The patient and chair are next turned laterally for the side views. The central sagit-

tal plane of the head must be exactly parallel to the Bucky and the position must be midway between flexion and extension. The exposures are always essential in this direction. The shift is 5 inches at the 44-inch distance, and should be lateral, in order that



Fig. 7. Anteroposterior view of an epileptic with marked mental deficiency, showing bilateral atrophy in the Island of Reil areas, poor filling of the cortical air spaces, and only partial drainage of the right ventricle.

shoulder will just clear the under edge of the Bucky. The restraining band is again used to fix the head (Fig. 3). Stereoscopic the basal cisternæ and ventricles will not seem distorted in their relation with the skull base in looking at a single roentgeno-

gram, or, more especially, its reproduction in a slide or print. The exposure factors for this view are 120 milliampere-seconds each, with a 6- to 7-inch gap. Similar lateral stereoscopic views are then made of the other side of the head. In these, it is well to place the lead side marker just below the level of the patient's ear, where its shadow will always be seen and it will not be in the way of any important structures. It is always well to have the upper cervical spine show on the lateral roentgenograms, for occasionally there may be a block in the region near or at the foramen magnum and it should be detected. This precaution was on one occasion the means of making a very important diagnosis in an obscure case that had been thoroughly studied and not detected by a number of other individuals. It was found that air failed to reach the cranial cavity and thus disclosed an obstruction due to an occipito-atloid dislocation.

General anesthesia is always conducive to failure in accurate and satisfactory encephalograms, and it should be avoided always unless it is absolutely necessary. The patient will not stop breathing and the proper manipulation and fixation of the head are extremely difficult. We have found it rarely necessary in adults, although it cannot be avoided very often in young children and infants.

The technic in children requires much less exposure. A higher milliamperage is required, and usually at the expense of the penetration factor for the sake of safety to the tube. In young children at the 44-inch distance we are employing the 100 milliampere Coolidge tube at 100 milliamperes and a 5-inch gap. With these factors, the sagittal exposures require three seconds and the lateral ones two seconds. A higher milliamperage may be used if more speed is required, but the voltage cannot, of course, be raised. Adequate exposure is the second requisite for satisfactory roentgenograms, and under-exposed ones are not only unsatisfactory but they may be misleading.

The third requisite for accurate work is that the encephalograms must be made within one hour after the air injection, as otherwise unnatural appearances are likely to be encountered. Also, the patient must not be permitted to assume the horizontal position until all of the exposures are made. With the proper equipment and a well trained group of workers, the entire roentgenographic procedure for the seven necessary exposures should not require over ten to twelve minutes from the time the patient is brought into the examining room.

Because of the vertical position of the patient, fluid cannot be drained from the descending or inferior horns of the lateral ventricles, and as a result no air enters these dependent portions of the ventricular system. Sometimes it is necessary to see them because of possible displacements, deformities, or obliteration. After the usual encephalograms are made in the erect posture it is quite easy to place the patient on the horizontal ventriculogram table and make lateral views, which will then show these missing portions of the cavities.

Some neurosurgeons prefer to admit the air by cisternal puncture into the cisterna magna. Roentgenograms made after this procedure are not as satisfactory because the air filling is never as complete as after the usual lumbar method of introduction. The reason for this is that the head cannot be so well manipulated for the drainage of fluid and the admission of air to all parts of the fluid pathways because free movements are restricted by the presence of the needle at a point of disadvantage. Cisternal punctures are occasionally necessary, but they should be avoided as routine procedures.

It will be noted from the foregoing description of an exact roentgenographic technic, that it, as well as a correct interpretation, depends to a very great extent upon the

surgical part of the procedure. The roentgenologist should be competent to take a stand that the latter must be carried out in a correct and advantageous manner, and his word should have due weight, just as in other combinations of minor surgical and roentgenographic procedures.

(B) THE PREPARATION OF THE PATIENT FOR ENCEPHALOGRAPHY (SURGICAL TECHNIC)

The indications for encephalography must be clear-cut in selecting the patient for this procedure. The slight risk and intense headache attendant upon the examination should militate against its use as a short-cut



Fig. 8. Normal anteroposterior view, showing convolutional markings without distortion or enlargement. The third ventricle, aqueduct, and fourth ventricle are usually seen.

to diagnosis. The case must have been carefully studied neurologically before attempting an encephalographic study. As

The visualization of the cerebrospinal fluid spaces and pathways within the skull requires the complete drainage of cerebro-



Fig. 9. Lateral view of the normal, showing hairpin-like markings and filling of the entire cerebral cavity by brain structure. Ventricles are normal. It is possible in this case to visualize the vermis in the cerebellum; fourth ventricle and aqueduct are clearly seen and cisterna venæ magnæ and cisterna chiasmatis appear slightly enlarged. Patient suffered from middle ear disease without intracranial complications. The absence of intracranial symptoms for the past nine months, as well as the negative neurological examination, taken with the encephalographic findings, leads us to believe this is a normal figure.

there are definite contra-indications to this procedure, these must be ruled out before undertaking encephalography. In suitable types of cases, it is a method of great value, and when properly performed has practically no risk or serious consequences. The resultant headache disappears in from three to five days, the patients promptly returning to their former degree of comfort and activity.

spinal fluid from the cranial cavity, and its replacement by air. This must be done with due regard to pressure relationships, and a constant reading of intracranial pressure by a manometer (mercury or water) must be maintained throughout the exchange of fluid and air.

It is at once evident that if a patient has a tumor mass in the posterior fossa, or ob-

struction to the outlet of fluid from the ventricles such as is present in internal hydrocephalus, cerebrospinal fluid cannot be properly drained from the cranial cavity or air introduced, and encephalography in this type of case is unsatisfactory and contra-indi-



Fig. 10. Right hemisphere of the brain showing the normal situation of Pacchionian granulations near the midline; their attachment to the dura, and the enlargement of fluid pathways in the sulci anterior to the area of thickening arachnoid seen from the motor cortex. Case of idiopathic epilepsy. (Preparation by Dr. N. W. Winkelman.)



Fig. 11. Compensatory pathways radiating from the cisterna venæ magnæ cerebri, which is greatly enlarged. Note the failure to fill any of the normal pathways over the frontal or parietal areas. The cisterna chiasmatis and pontis are not filled, although the ventricles and cisterna venæ magnæ show no obstruction. This case proved to have an obstructive arachnoiditis in the cerebellopontile angle, thus preventing air from reaching the cortex in the usual way, a compensatory mechanism to the vertex being established

cated. Far more important is the danger such cases present, because they usually are attended by increased intracranial pressure and the withdrawal of spinal fluid may allow the brain to expand in the direction of the release of pressure so as to force the cerebellar hemispheres into the foramen magnum, producing a hernia with pressure on the medulla, and respiratory failure. This is a real danger and has led to the adoption of an arbitrary level of pressure above which we believe encephalography is unsafe.

It is our opinion that encephalography is contra-indicated when spinal fluid pressure is above 20 mm. Hg, with the patient in the horizontal position and resting quietly. Pressures above 20 mm. Hg are usually associated with some profound obstruction to the cerebrospinal fluid circulation and require careful consideration to rule out a posterior fossa lesion or obstruction in the outlets to the ventricles, making encephalography dangerous, as well as unsatisfactory.

When a careful history and neurological examination have shown the patient to be suffering from cerebral symptoms, and lumbar puncture indicates spinal fluid pressure below 20 mm. Hg in the horizontal position, encephalography may be indicated and safely performed.

We have found the safest and easiest

method of air injection to be the following: The patient is placed on a litter in the horizontal position, with knees drawn up preparatory to a lumbar puncture. The skin in the lower lumbar region is carefully prepared with alcohol and iodin. The operator should wear sterile gloves and maintain careful aseptic technic throughout. Novocain is introduced in the skin over the fourth and fifth lumbar interspaces, respectively. A lumbar puncture is then done, using an eighteen gauge "Green" round-point, or "Babcock" nickeloid steel needle. The spinal manometer is connected to the needle, and the initial pressure reading made. The normal pressure in this position should be about 8 mm. Hg. If the pressure is above this level, such as 14 or 16 mm. Hg, spinal fluid is allowed to drain from the needle until the pressure has fallen to 8 mm. Hg (Fig. 4).

If the pressure reading is 20 mm. Hg or over in this position, the encephalogram is contra-indicated, unless the operator deliberately assumes the added risk where localization or confirmation of a lesion is imperative. It is better, provided encephalography is desirable, to actively dehydrate the patient for several days and again make a pressure reading, as frequently reduction of intracranial pressure resulting from dehydration makes possible a safer level of pressure to carry out the procedure. With the finding of the pressure below 20 mm. Hg, a second spinal needle is introduced one interspace higher, the manometer disconnected, and the stilets of the needle replaced. With two needles in place, the patient is then carefully raised to the sitting position or transferred to the encephalogram chair, with the head in the midline and flexed slightly forward (Fig. 5).

The manometer is now connected again with the upper needle and should register in the normal adult about 20 mm. Hg. The change of pressure from 8 mm. Hg in the horizontal position to 20 mm. Hg in the sitting position is due chiefly to the height of the spinal canal, and the added weight of the column of fluid in the upright position. Patients with short backs often show 16 to 18 mm. Hg of pressure, whereas, those with longer spinal canals may register 26 to 28 mm. Hg, the average normal pressure in the sitting position being about 20 mm. Hg. It is evident that should the patient have increased intracranial pressure in the horizontal position, such as 18 mm. Hg, and then be raised to the sitting position, the pressure may reach 40 mm. Hg, a level felt to be too high for safety. It is for this reason that fluid pressure when over 8 mm. Hg in the horizontal position, is allowed to fall to 8 mm. Hg before placing the patient in the sitting position preparatory to continuing the spinal drainage.

With the patient in the sitting position and the manometer connected to the upper needle, the stilet is withdrawn from the lower needle and spinal fluid allowed to drop from the needle until the pressure has fallen from around 20 mm. Hg to 10 mm. Hg. This usually occurs when from 15 to 30 c.c. of spinal fluid has escaped. With a sterile 20 c.c. syringe, air is now introduced into the lower needle, watching the pressure on the manometer until it has been raised again to 20 mm. Hg. This may require 5, 10, or 15 c.c. of air, but it is important not to try to replace air in equal amounts for fluid obtained. The pressure readings indicate the safest amount that can be replaced at each interval so as not to produce an increase in intracranial pressure. Room air expands when raised to body temperature, and thus the "volume for volume" method produces increased intracranial pressure and disturbing symptoms in the patient. The "pressure for pressure" method maintains the patient in a constant regulated equilibrium, and has not been associated with any untoward symptoms in our experience (Fig. 5).

With the introduction of the air and the rise of pressure to 20 mm. Hg, drainage from the lower needle is again permitted un-

til the pressure falls to 10 mm. Hg, when 10, 15, or 20 c.c. of air is introduced, depending upon the amount required to raise the pressure again to 20 mm. Hg. This procedure is repeated until the entire amount of

head is carefully rotated, flexed, and extended. The chin is depressed to the chest, and then slowly elevated so that the head is extended. Rotation of the head is carried toward the shoulder and back to the midline,

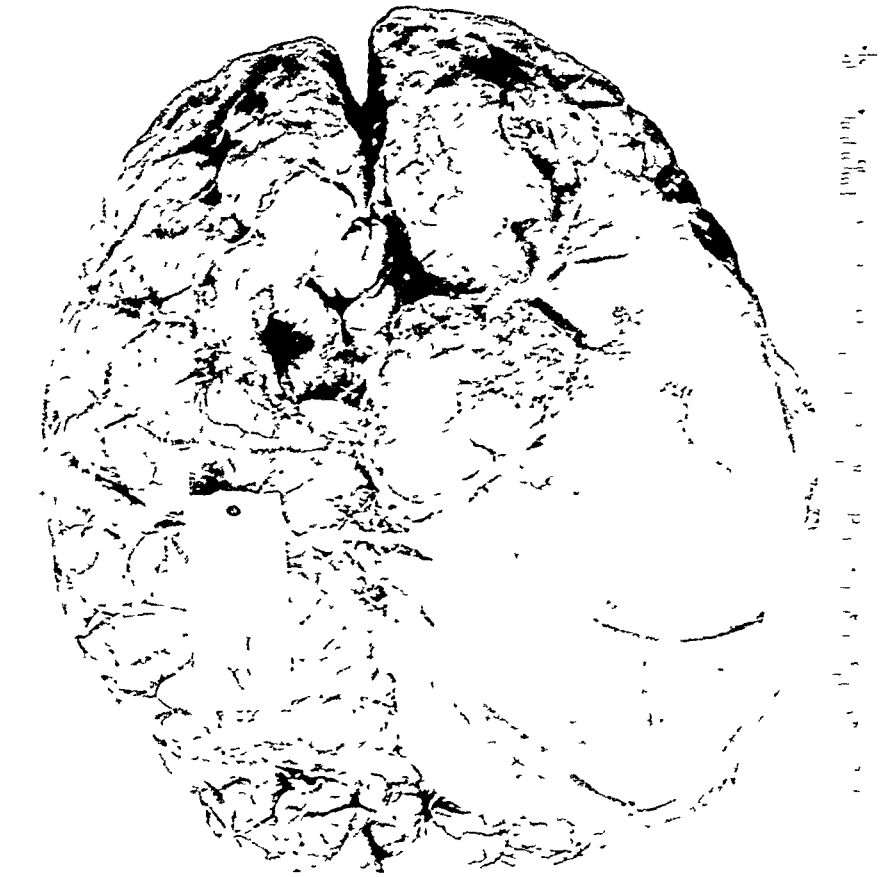


Fig. 12. Large midline endothelioma, showing pressure atrophy of the brain and enlargement of fluid spaces in the region of the tumor. Cortical pathways are obliterated on the lateral surface of the brain due to flattening of the convolutions. Fluid pathways in the frontal lobe show enlargement with pressure atrophy behind the point of obstruction by the tumor. (Preparation by Dr. N. W. Winkelman)

cerebrospinal fluid that can be obtained has been replaced by air, the point being indicated by the return of bubbles from the needle. *At least 100 c.c. of air* should be used to insure a satisfactory encephalogram.

During the period of drainage and replacement of spinal fluid by air, the patient's

first to one side and then to the other. The head is always returned to the midline before beginning a new series of movements. The regular movements of the head should be carried on during the drainage and should include ten or more repetitions of each movement. Jarring the head slightly

with the open palm seems to assist in draining the smaller pathways, and this should be repeated three or four times. It is most important that the entire procedure be carried out in the sitting position and the head maintained in the midline, not only for the period of injection, but also during the time required to take the patient to the roentgenological department, and throughout the entire roentgenographic procedure. If the patient is allowed to lie down, or the head permitted to incline to one side, air will rise in the fluid spaces to the highest point and produce unequal distribution and misleading effects, which vitiate attempts at interpretation later.

The roentgenologist requires perfect and uniform technic by the operator in his introduction of the air so that proper interpretation of the roentgenograms can be made. Too much emphasis cannot be placed on the proper manipulation of the head during the injection period, and its maintenance in the midposition at all times subsequently, even though the patient may desire to lie down.

There are definite symptoms which accompany the period of air injection which may disturb the operator if he is not familiar with their occurrence. The patients complain of severe frontal headache early in the injection, sweating breaks out on the forehead and becomes generalized They may feel faint and frequently vomit during the procedure. The pulse may become rapid, or slow down to sixty beats per minute. These symptoms are almost always present during the procedure and need not alarm the operator if careful manometric readings indicate that the intracranial pressure has not been increased above 20 mm. Hg at any time. Chloral hydrate given before and after the procedure assists in the control of headache and the comfort of the patient. The gradual replacement of fluid bv air gives the least reaction. *Fluid should never be sucked out of the spinal canal by the syringe.*

The patient is usually left with 10 mm. Hg of pressure at the termination of the air injection. It will be found frequently that there is 10 to 12 c.c. more fluid withdrawn





Figs 13 (*left*) and 14 (*right*) Anteroposterior and lateral views of case of endothelioma in the parietal lobe. Note displacement of the structure at the midline away from the tumor, with depression of the roof of the ventricles on the left, characteristic failure to fill cortical air spaces Tumor removed at operation by Dr Frazier



Fig. 15. Compensatory pathways over the frontal region passing through a field of arachnoiditis. Note evidence of chronic intracranial pressure by enlargement of cisterna chiasmatis pontis and the fourth ventricle and unilateral dilation of the lateral ventricle.

than air introduced, and this difference in volume may be accounted for by expansion of air and engorgement of the cerebral vessels. As long as the final pressure remains the same as the original pressure, a safe balance is maintained.

With the completion of the introduction of air, the spinal needles are withdrawn and the patient placed in a wheel chair and maintained in the upright position while being taken to the roentgenological department, or better, the surgical procedure should be carried out in the same chair as is used for the roentgenographic exposures (Fig. 1).

NEURO-ANATOMICAL RELATIONSHIPS

As the surfaces of the brain visualized by encephalograms are those surrounded by gross amounts of cerebrospinal fluid, it is important to have clearly in mind the characteristics of these spaces as found in what may be considered the normal. Tracing the course taken by cerebrospinal fluid in its circulation from its source within the ventricles to its points of absorption at the periphery, a clear understanding of the defects which may be produced by obstructive lesions can be gained.

It has become accepted that cerebrospinal fluid is elaborated for the most part through the choroid plexuses, situated in the lateral, third, and fourth ventricles of the brain. Fremont-Smith (13) has shown that it is a dialysate from the blood plasma, and similar to other tissue fluids (edema and ascites) in its protein content. He points out its

similarity in this respect to glomerular urine, analyzed by Wearn and Richards (36). The amount of this fluid produced each day may vary greatly. It is variously estimated at from 30 to 50 c.c., though it is known in cases of cerebrospinal fistula to be produced at the rate of 200 to 700 c.c. daily. The failure of this fluid to escape properly from the ventricles produces the well-known type of internal hydrocephalus. The lateral ventricles communicate with the third ventricle by merging toward the base of their anterior horns, leaving an opening, the foramen of Monro (Fig. 6-*A*). It is at once evident that if an obstruction occurs at the outlet of one ventricle, the accumulation of spinal fluid will produce a unilateral dilatation which will push the midline structures to the opposite side, encroaching upon the lumen of the other ventricle. At the same time pressure atrophy of the brain occurs and the enlargement of the ventricle takes place in all directions, as we have previously shown (24). When a unilateral dilatation of a ventricle is found by encephalogram, it at once indicates that the obstruction producing the dilatation no longer exists, as air could not have entered it otherwise. Such a finding would indicate a process which had occurred early in the history of the case, and finally reopened the outlet, after its dilatation had reached a point of overcoming the obstruction.

The failure of one ventricle to fill does not necessarily indicate a pathological obstruction, as this defect has been noted in cases where improper manipulation of the head had occurred, or some error in the technic of air injection existed (Fig. 7). The fluid emptying from both lateral ventricles into the third ventricle passes into the aqueduct of Sylvius on its way to the fourth ventricle (Fig. 6-*D*). It is in this narrow aqueduct that obstructions frequently occur, leading to an internal hydrocephalus, characterized by symmetrical dilatation of both lateral ventricles, and the third ventricle as well.

If the lateral ventricles fill with air, it is *prima-facie* evidence that there is no existing obstruction in the ventricular system. We cannot state dogmatically the exact normal size and shape of the lateral ventricles in the living subject nor the variations within normal limits (Figs. 8 and 9). There are many reasons for this. In the first place, encephalographic procedures have not been carried out upon many known normal subjects, and the best we can do is to collect a large number of encephalograms that are interpreted as negative and from these decide as best we can what a normal size and appearance would be. Secondly, there has been, up to the present time, little uniformity in roentgenological technic, and the procedure must become standardized. Thirdly, the operative technic must be similarly standardized. Naturally our interpretation as to the configuration and size of these ventricles must be based in all instances upon the two sagittal and the lateral views. The obliteration of the angle in the roof of the lateral ventricle at the juncture of the body and posterior horn as a sign of enlargement or dilatation, as once suggested by Dandy (6), does not hold good, as it will not disappear until great dilatation occurs. The foramina of Monro are usually perceptible normally and become progressively wider with dilatation.

The third ventricle configuration as shown in the lateral view corresponds closely to the text-book description. It enlarges in all directions, with its shape and irregularities fairly well preserved until it becomes quite large. The greatest enlargement seems to be downward and forward to the sella turcica. The aqueduct is always a rather narrow channel and, while it does widen under pressure, the increase does not keep pace with the widening of the foramina of Monro or the dilatation of the lateral

ventricles. Tumor masses arising in the third ventricle may obstruct the opening to the aqueduct and also produce an internal hydrocephalus. A filling defect of the third ventricle is usually apparent, however, and is thus distinguishable from a lesion within the aqueduct itself. Tumors of the fourth ventricle obstruct the outlet for spinal fluid at the lower end of the aqueduct, and thus produce a dilatation of the aqueduct, as well as the third and lateral ventricles.

It is at once evident that lesions situated in this area sufficient to block the outlet of spinal fluid, also prevent air from entering the ventricles, and hence no filling of the ventricles is possible by the lumbar insufflation of air. In these cases, ventricular puncture by means of a trephine through the skull in the occipital region is the means by which such obstructions are shown. Air is introduced directly into the ventricles and the procedure is known as ventriculography. It is not only impossible to introduce air by the lumbar route into the ventricles when



Fig 16. Distortion of the ventricles and displacement of the midline structures due to glioma in the right temporal lobe. Note dilation of the opposite ventricles Absence of cortical air markings illustrates obliteration of fluid pathways over both hemispheres

an obstructive lesion is present in the third or fourth ventricles, but it offers a very distinct danger to the patient, and is considered the greatest contra-indication against encephalography.

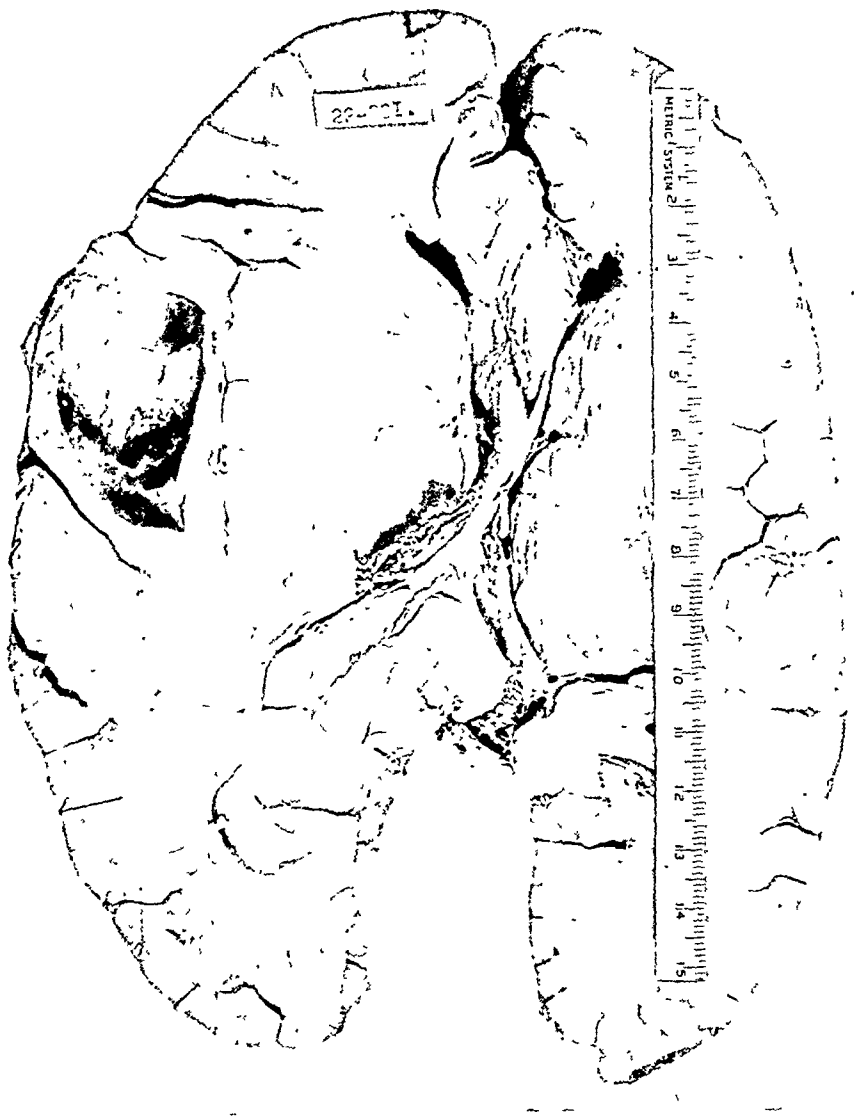


Fig. 17. Gliomatous brain, with cystic degeneration. Notice the filling defect of the ventricles, "ironing out" of the sulci, and flattening of the convolutions, not only on the side of the tumor but on the opposite side as well, due to increase in volume in brain and displacement beyond the midline. (Preparation by Dr. N. W. Winkelman.)

The danger is a real one, due to the trapped fluid within the ventricles being under pressure. If spinal fluid be withdrawn from the lumbar sac in such a case, the fluid under pressure within the ventricles may force the tips of the cerebellar hemispheres into the foramen magnum, and produce a hernia. The pressure of such a herniation upon the medulla may produce a rapid re-

spiratory failure, and death. This has been found to be a frequent cause of death in brain tumors, either spontaneously or short-



Fig. 18. Widespread arachnoiditis of the cortex in the presence of ventricular deformity. Evidence of brain destruction indicated in the large collection of air in the region of the Island of Reil on the side of the ventricular deformity. Post-traumatic epilepsy developed eight years after a fall of twenty-eight feet.

ly after lumbar puncture, and experience in this mechanism has led to the avoidance of such a circumstance when undertaking encephalography.

Cerebrospinal fluid escapes from the fourth ventricle through the foramina of Luschka and Magendie into the subarachnoid spaces about the medulla, in the region of the foramen magnum (Fig. 6-*A*). There may be a membrane over the outlets of the foramina of Luschka and Magendie, shown by Bateman (2) as occurring in a small percentage of mental defectives. It is possible under such circumstances that fluid might pass through the membrane, but it would be

impossible to introduce air into the ventricles. Such an explanation for the occasional failure of the ventricles to fill when no increased pressure exists, or signs of posterior fossa lesion are present, may be offered in certain cases, but the majority of failures to fill the ventricles we believe to be an error in the technic of air injection. If the procedure is repeated and a similar result obtained, after careful rotation and manipulation of the head, the possibility of such a lesion may be considered. If possible, the patient should have a ventriculogram to establish the size and position of the ventricles before a positive diagnosis can be made. In several cases we have found that a roentgenogram taken twenty-four hours later showed air within the ventricles when no filling was seen at the time of the encephalography.

Occlusion of the aqueduct of Sylvius may occur from the overgrowth of neuroglia and, by its obstruction, simulate other forms of obstruction, as by tumor.

We wish to emphasize the fact that obstructive lesions situated between the third ventricle and the outlets from the fourth ventricle offer a distinct contra-indication to encephalography, not only because of the inability to obtain a satisfactory visualization of the ventricular outline, but also because these lesions are usually associated with increased intracranial pressure, due to an internal hydrocephalus, and may produce consequences dangerous to the patient because of a foramenal hernia, if spinal fluid is withdrawn.

There has been but one death in our series of 117 cases and this fatality occurred three days after encephalography. The patient had a huge right hemispheric glioma. The procedure was undertaken with full knowledge of the increased risk in such a case, as gliomas may produce rapidly fatal symptoms following even lumbar puncture. The futility of operation in this case was demonstrated by encephalography, and later verified at autopsy.

It is our opinion that the safety of the procedure lies in careful consideration of the neurological symptoms, and especial regard to the spinal pressure. If the pressure is found to be 20 mm. Hg or over, the likelihood of a severe form of obstruction contra-indicates the procedure until pressure may be reduced below this point by dehydration or the history and findings clearly rule out a posterior fossa lesion.

In tracing the spinal fluid after it leaves the foramina of Luschka and Magendie, we accept the views of Weed (30) that the major points of absorption for this fluid are the subarachnoid villi and Pacchionian bodies. The principal collection of these structures is at the vertex (Fig. 10). A small amount of spinal fluid escapes along the nerve roots of the spinal canal, as Weed has demonstrated. Recently Hassin (23) has shown arachnoid villi present about the spinal nerve roots, although he does not attach the value to them of filters for cerebrospinal fluid. A group of these villi are also found in the cisternæ venæ magnæ cerebri (Fig. 6-*F*). They are most numerous, however, on each side of the longitudinal sinus in the frontoparietal area of the brain.

Spinal fluid must, for the most part, find its way from the region of the posterior fossa where it first becomes subarachnoid, into the cisterna magna and pontis, thence through the incisura tentorii, to the cisterna chiasmatis, where it is distributed about the infundibulum and chiasm (Figs. 6-*A* and 6-*F*). It then finds its way along the Sylvian fissures on each side and between the frontal lobes of the brain in the midline (Fig. 6-*B*), thence by devious channels formed by the sulci between the convolutions of the brain to the vertex. The field of cortical circulation is confined to the surfaces (mesial and lateral) of the frontal lobes, and as far posteriorly as the Sylvian



Fig. 19. Anteroposterior view of six-months-old infant showing spasticity and convulsive seizures following birth trauma. Note unilateral brain atrophy on one side and undrained area probably associated with arachnoiditis as well as atrophy on the other. Great enlargement of the cisterna venæ magnæ cerebri.



Fig. 20 Cortical atrophy seen in nine-months infant following birth trauma. Note the increased air in the region of the Island of Reil, with marked involvement of the frontal pole. No ventricular filling, probably due to insufficient air.

fissure and its juncture with a line drawn to the parieto-occipital sulcus (Figs. 6-*A* and 6-*H*).

It is important for the roentgenologist to be familiar with the approximate normal size or width of the cortical pathways as well as their normal distribution. As in the case of the lateral ventricles, we cannot determine measurements from known normal subjects, and must obtain an approximate idea of what should be normal from the study of a large number of negative cases in which no lesion could be demonstrated. This seems to be a reasonable deduction provided the general appearances in such cases are practically identical (Fig. 9). If one looks at a flat lateral roentgenogram of such a case, there are two general sizes of cortical pathways. One is narrow and corresponds to the size on the side examined, while the wider pathways correspond to those seen through from the opposite side. These can be differentiated in the stereoscope, but one cannot measure such narrow spaces stereoscopically with accuracy. In the past, we have been accustomed to describe the supposedly normal cortical pathway as of hairpin size. Recently, the Encephalogram Committee appointed by the American Roentgen Ray Society (12) determined the width of the normal pathway on the side being examined as approximately 1 mm. and the projected pathways from the opposite side and seen through as approximately 3 millimeters. Midline pathways are readily distinguished from those over the cortex by the fact that they arise from a sagittal channel above the level of the corpus callosum (Fig. 6-*B*), whereas the lateral cortical pathways arise lower down (Fig. 6-*A*).

In its subarachnoid course from the posterior fossa forward spinal fluid must pass through the narrow channels on each side of the pons caused by the incisura. It is at this point that relatively small tumor masses,

such as acoustic tumors or cerebellopontile angle tumors, may effectually block one side and displace the structures, so that they obstruct the opposite pathway. In this type of case when the stage of obstruction is reached, pressure rises rapidly, and choked discs, with headache and vomiting, indicate the signs of intracranial pressure.



Fig 21. Cystic areas of fluid and resultant pressure atrophy in a case of idiopathic epilepsy. Note the scarcity of normal Pacchionian bodies, the enlargement of the fluid pathways over the frontal and parietal areas, and the complete escape from this process in the temporal occipital regions of the brain (Preparation by Dr. N W. Winkelman)

Because of the high pressure and the possibility that the tumor may press sufficiently against the pons to close the aqueduct of Sylvius, encephalography has been considered as contra-indicated, or certainly attended by more risk than usual in this type of case. However, the procedure in our hands has shown clearly the point of obstruction in several cases. Fluid accumulations greater than normal are seen about the posterior fossa by the air injection method in such cases. The cisternæ pontis and magna are enlarged. Air does not show in the cisterna chiasmatis region, or over the cortex, thus demonstrating the block to be at the level of the incisura (Fig. 11). Occasionally the ventricles do not fill, due to closure of the aqueduct by pressure. The findings are similar to those in cases in which obstruction exists just above the incisura on the chiasmal side. It will be noted that the structures at the base are well shown for the posterior fossa, but no air is seen above the tentorium or in the ventricles.

In the consideration of the lesions above the tentorium we enter the field of greatest



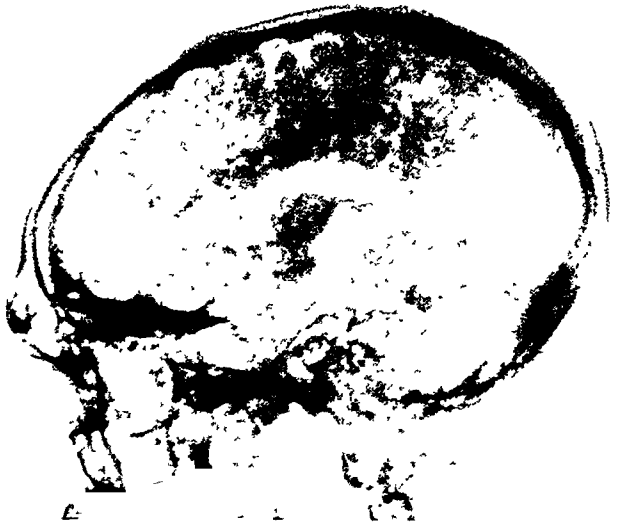


Fig. 22 (*left*) and Fig. 23 (*right*). Post-traumatic epilepsy, with arachnoiditis on the left, and cortical atrophy on the right. Operative verification showed diffuse collections in the subarachnoid spaces, with arachnoiditis in the right motor areas secondary to trauma.

possibilities for encephalography, and the danger of the procedure becomes very slight if the precautions already mentioned have been observed. It is evident we are less likely to have lesions involving the cerebral hemispheres that can obstruct the important outlets from the ventricles and thus offer distinct dangers to spinal drainage.

The diagnosis and interpretation of lesions affecting the cerebral hemispheres rest upon the knowledge of the normal pathways for cerebrospinal fluid and their size and distribution. Figures 6-*A* to 6-*H* give diagrammatic representations of the course taken by fluid to reach the vertex, its chief area of absorption. It is evident that as the many fluid channels diverge from the cisterna chiasmatis at the base, it would require a very large tumor to produce obstructive signs and pressure. An inflammatory process would easily block many channels and readily produce symptoms.

Encapsulated tumors here, such as endotheliomas, may reach large proportions before producing signs of pressure, focal signs appearing frequently before the headache, vomiting, and choking of the discs (Fig. 12). This is due to the fact that a solid tumor mass, for instance in the right lower motor area (Sylvian fissure, Fig. 6-*H*), obstructs the channels for fluid at this point, but as there are many other pathways still open (*viz.,* between the frontal lobes, anteriorly over the frontal pole, the opposite side, etc.), the tumor may continue to enlarge until by its added volume and the compensating shift of the brain structures there is a constant cutting down in size of the compensatory pathways (Figs. 13 and 14). The time arrives when fluid can no longer reach the vertex easily, and back-pressure begins. This produces a vicious circle in that with the increased pressure back toward and into the ventricular system the cortical surface of the brain is pressed against the dura and skull, with further obliteration of the fluid spaces and channels. This results in great deficiency in circulation of fluid and a further rise in pressure. Generalized symptoms of intracranial pressure ensue. Such a lesion produces an encephalographic study such as is seen in Figure



Fig. 24. Compensatory pathways of the vertex in a case of abnormal calcification over the frontal region. Evidence of arachnoiditis in the parietal area. Patient had chronic headache throughout life; history of many falls from horse



Fig. 25 Lateral view showing area of decompression following trauma. Thirteen years later patient developed convulsive seizures, but has maintained civil service position in a post office to the present time. Extensive cerebral atrophy, with dilation of the cisterna venæ magnæ cerebri.

11, with dilatation of the cisterna chiasmatis and failure to fill or drain the cortical pathways, due to obliteration or blockage. A few compensatory pathways may be found to still remain. The obliteration of an area of usual fluid spaces indicates either trapped fluid or pathways filled with reactive or inflammatory tissue (arachnoiditis, *e.g.,* Fig. 15). The size and location of the tumor can be determined in the stereoscopic views when the ventricular distortions, combined with the characteristic lack of cortical air markings, indicate the location and extent of the lesion (Fig. 16).

Gliomas produce a somewhat different mechanism of pressure, and hence an encephalographic study that is quite diagnostic. As gliomatous tumors are invasive and produce a reactive gliosis as they spread, they increase the bulk of the brain in such a way that the convolutions become larger and are pressed more closely together, thus obliterating the fluid pathways in the sulci between them (Fig. 16). A soft, flattened, yellowish surface is characteristic of glioma when viewed at operation. In the "ironing out" of the cortex by the glioma the fluid spaces are decreased. The volume of the hemisphere enlarges and frequently extends across the midline (Fig. 17). The increased volume displacement soon affects spaces on the normal side and a point is reached when compensation no longer occurs.

Pressure beginning in this type rapidly increases and produces permanent mechanical obliteration of channels, which do not reestablish themselves even after removal of a mass of the tumor or after decompression The discouraging aspect of the glioma problem has been the failure to overcome the final pressure factors, even after a good decompressive opening and ample removal of tumor mass. The early recognition of these lesions before these changes have reached a permanent state is offered by encephalography, and the safety of the procedure when undertaken before the high pressure stage appears has been well demonstrated.

Beside the usual obliteration of the fluid spaces in a glioma case the ventricular out-



Fig. 26 Anteroposterior view showing marked atrophy of both hemispheres in a case of post-traumatic epilepsy. Note enlargement of the cisterna venæ magnæ cerebri, midline cortical air markings, and area of decompression at the site of injury (fifteen years prior to encephalogram).

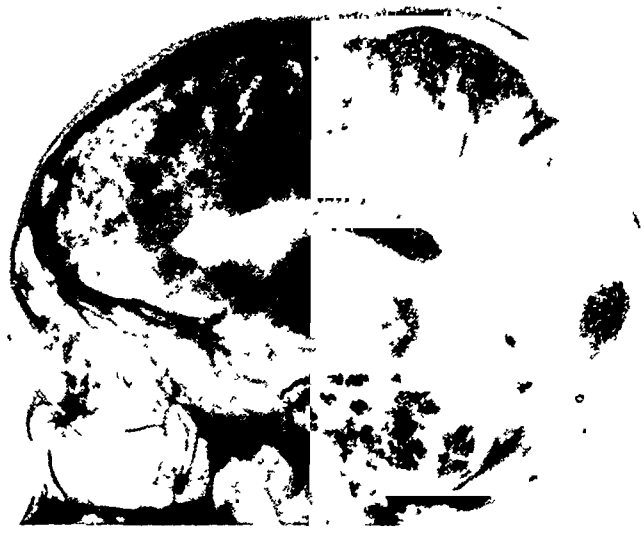


Fig 27. Focal cortical atrophy present in the parietal area in a case of epilepsy.

line may be well preserved, but the shape diminished as though by a general invasion to its walls (Fig. 16), thus reducing the outline. If a cystic mass be present, the same distortion noted in the solid encapsulated tumor results.

The differential diagnosis between areas of inflammatory obliteration and glioma when seen on the encephalogram lies mainly in the study of the ventricular spaces and the cisternæ. Inflammatory reactions if subacute or chronic give rise to the generalized increased collections of fluid behind the point of obstruction, so that the ventricles and cisternæ appear to be slightly enlarged, and instead of being distorted or obliterated actually show evidence of loss of brain volume by increase in size (Fig. 18). In such cases the areas showing loss of cortical air markings indicate either undrained fluid (trapped) or adhesive arachnoiditis (plastic exudate). This type is fairly frequent, especially among the post-traumatic, paretic, epileptic, birth injury, and mental defective cases (Figs. 19 and 20).

ARACHNOIDITIS

The process of arachnoiditis is recognized grossly at operation by a milky appearance of the arachnoid covering the cortex. It is found to be thickened and the layers of the pia and arachnoid are fused together by reactive tissue in such a way that the pathways for fluid are greatly impaired. These areas may appear cystic, as described by Dandy (9), and with the increase in fluid around them there are deepening and widening of the sulci, with evidence of actual convolutional atrophy (Fig. 21). At times the process is diffuse, so that a generalized edema is present, and fluid is held within the meshes of the spongy arachnoid patches in such a way that it is *impossible to drain it by the lumbar route.* Even with the direct operative exposure of these areas and the opening of the arachnoid it is difficult to dislodge these fluid collections even by gentle massage of the edematous area and

stroking the fluid toward the arachnoid opening. In dealing with this type of trapped or edematous collections of fluid one is reminded of soggy wet bread. In several instances operative exploration has immediately followed encephalography and the areas where no air appeared on the roentgen films have showed that fluid remained undisturbed at these points though air was present in the open channels surrounding them (Figs. 22 and 23). The diagnostic interpretation of these undrained and obstructive areas rests with the history of the case or the advanced signs of atrophy present, suggesting an old lesion, possibly of traumatic or inflammatory origin (Fig. 18). The appearance in the encephalogram may indicate arachnoiditis, but the roentgenologist should bear in mind that the area may contain a large amount of trapped fluid, thus disguising the underlying atrophy (Fig. 19).

In some cases (Fig. 24) compensatory channels arise to allow fluid to find other pathways to the vertex when the normal fields have been blocked. We have seen one such case in which no air appeared over the fronto-parietal field on either side, but a large pathway had developed posteriorly by way of the cisterna venæ magnæ cerebri and thence between the occipital lobes, to reach the mid-hemispheric region above the corpus callosum from behind (Fig. 11). Such a compensatory mechanism arising after a block in the fluid pathways leading from the cisterna chiasmatis would seem to explain the absence of pressure symptoms which usually occur when no progress for fluid exists in the normal channels.

POST-TRAUMATIC CHARACTERISTICS

The post-traumatic group gives rise to two types of characteristic findings of various degrees. Subarachnoid hemorrhage produces not only organization at the site of the clot but also, according to the work of Weed (29, 30) and the pathological studies of Bagley (1), to an intense reaction of the pia-arachnoid due to the presence of red blood cells. Fibrosis follows the period of reaction and the normal free fluid spaces become sealed off or greatly obstructed in this process. The neuropathological studies of Winkelman (37, 38) confirm these experimental observations as actually present in man. The encephalogram shows little or no air in these areas, but generalized enlargement of the fluid pathways at a distance as though obstruction of cerebrospinal circulation to the vertex had produced back-pressure and dilation of the fluid spaces behind the point of obstruction (Figs. 20, 25, 26, 27, and 28).

When trauma has actually destroyed brain tissue by its force, gliosis and fibrosis in time lead to contracture of the brain. It is in this group that we may see the wall or roof of the *ventricle drawn toward the surface of the brain* (Fig. 18). The surface markings may show evidence of obliteration at this point (Fig. 18), or, if marked loss of brain has occurred, there may be great atrophy of the cortex, as shown by increase in the air markings associated with a dilated ventricle on the side of the atrophy. This is particularly true in thrombotic lesions; the gross pathology of ventricular enlargement and cortical atrophy is clearly shown in a study of Figures 28, 29, and 30.

The differentiation between mass lesions such as tumor, cyst, or abscess is best shown in the study of Figures 13, 14, and 16, as compared to Figures 15 and 18. Here filling defects and distortion of the ventricles occur but always *away* from the site of the lesion, frequently with a shift of the midline structures to the opposite side. If a solid tumor of sufficient size is present, it will not only obliterate the fluid spaces over the cortex where it is situated but may depress the wall of the ventricle and by stereoscopic

study of the encephalographic films give definite evidence of its relative size and location.

As has been already pointed out glio-

pathways normally present in the sulci between the convolutions, but also to encroach upon the ventricular lumen, producing a small or deformed ventricle.

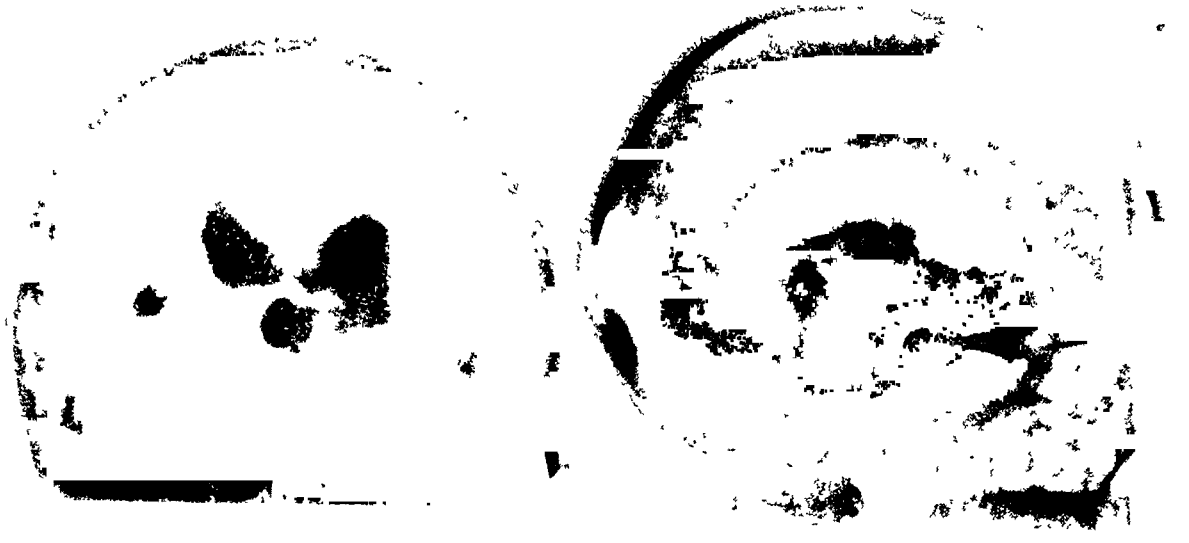


Fig. 28 Anteroposterior view showing slight cortical atrophy (unilateral), with increase in cortical air markings on the opposite side. Normal ventricles.

matous tumors are invasive and swell the bulk of the hemisphere in such a way as not only to obliterate the cortical markings by flattening the cortex and filling in the fluid

GENERALIZED BRAIN ATROPHY

When the obstruction occurs at the outlets for cerebrospinal fluid along the longitudinal sinus and the large veins, we observe



Figs. 29 (*left*) and 30 (*right*). Encephalograms in case of progressive mental deterioration and blindness. Speech became indistinct, there was loss of orientation and judgment, with gradual paralysis. No choking of the discs; Wassermann negative. Note the generalized arachnoiditis over the frontal lobes, with one remaining compensatory pathway.

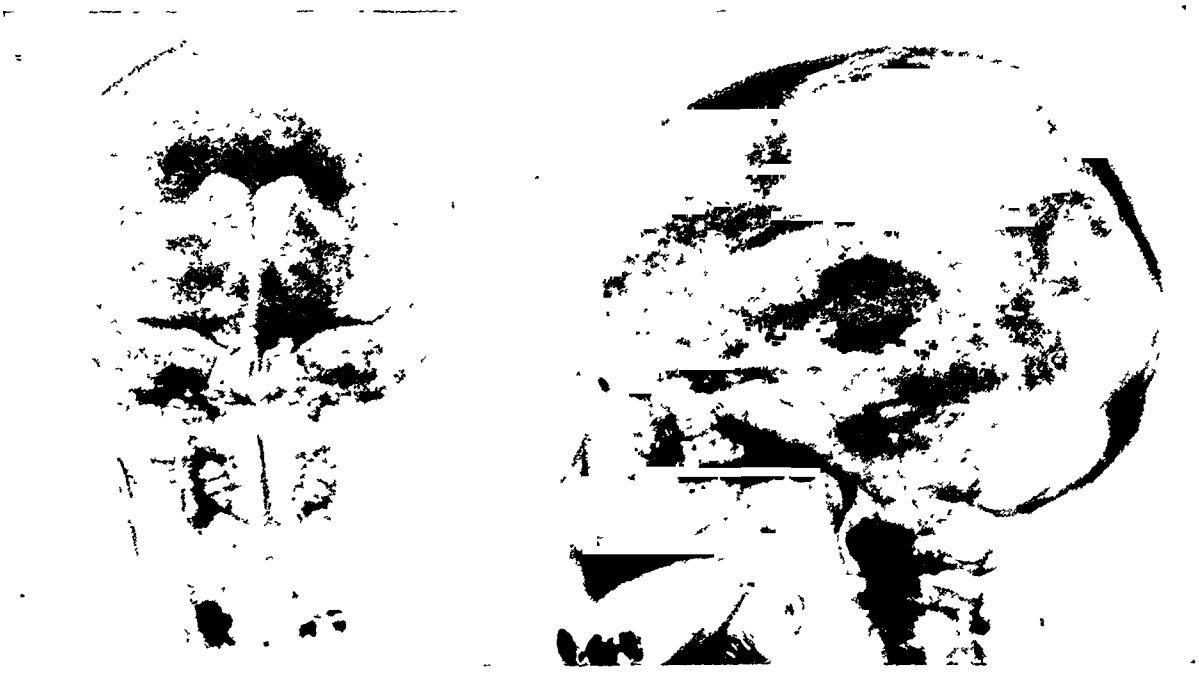
In the anteroposterior view the ventricles are shown dilated but on each side is an increased collection of air in the region of the Island of Reil.

The lateral view shows not only the atrophied area in the Island of Reil, with irregular cyst-like collections of air, but more striking is the marked atrophy of the occipital pole in the region of the cuneus. This, we believe, accounted for the blindness, the speech defect being due to the atrophy in the Island of Reil area, and the frontal lobe signs of mental failure to the arachnoiditis.

As the patient had increased spinal pressure a brain tumor was suspected until the encephalogram showed the multiple areas of atrophy, accounting for the symptoms described.

increase in the fluid spaces behind this point, with dilatation of the pathways over the parietal and frontal area and typical cerebral atrophy. It should be noted that the atrophy is almost always confined to this area, no matter what the cause for disturbance in the final outlets for fluid may prove to be. This atrophy, so typical in the mental defective and imbecile groups, whether due to birth injury, meningitis, or trauma in later life with subarachnoid hemorrhage, has been shown by Winkelman to have in common marked deficiency or destruction of the Pacchionian system (Figs. 19, 20, 25, 26, 27, and 28).

We have discussed elsewhere (21) the question of hydraulics producing this type of atrophy, which we believe to be a pressure atrophy of the ischemic type. The fluid spaces of the fronto-parietal areas communicating as they do grossly may permit a "fluid cast" to encase this area of the brain, and this "fluid cast" registers constantly the various changes of pressure within the closed skull on the walls of the pathways (*i.e.*, the fronto-parietal convolutions). This we believe would produce a pressure atrophy on the soft tissue of the brain similar to the pressure atrophy we see in the soft tissues of the extremities when a close-fitting cast is applied to the part. There seems no other plausible explanation for the selective atrophy which is so frequently closely confined to this area of the brain when compared to the adjacent temporo-occipital areas, the only striking differences morphologically be-



Figs. 31 (*left*) and 32 (*right*). Epilepsia tarda in a woman of forty-five. Note calcification of the Pacchionian bodies on each side of the midline: slight atrophy in the region of the Island of Reil: cerebellar atrophy.

ing the presence of these gross fluid channels normally in the fronto-parietal region and their absence in the temporo-occipital area.

The interpretation which we have placed upon the finding of enlarged fluid spaces and increase in the size of the air shadows over this portion of the brain is not only one of cerebral atrophy, but that a deficiency, block, or degenerative change has taken place at the portals of elimination for cerebrospinal fluid, the exact nature of which depends upon the history and physical findings of the case.

The pathological changes noted by Winkelman (37, 38) in the Pacchionian bodies, associated with increased fluid accumulation and consequently cerebral atrophy, are (*a*) aplasia, congenital absence of these structures; (*b*) hypoplasia, infantile type, with marked failure of proper development; (*c*) hyperplasia, acutely swollen and enlarged Pacchionian bodies, found in toxic, eclamptic edema; (*d*) infiltrative invasion of the structures by red cells, leukocytes, inflammatory tissue, and occasionally cancer cells; (*e*) sclerotic, degenerative changes, with shrinkage of the structure, a loss of its characteristic architecture and its replacement by fibrous tissue and calcium deposits.

Calcification of the Pacchionian bodies has been noted as a fairly constant finding in later life, but our encephalographic studies would seem to indicate that in cases in which the process was marked it was associated with increased fluid accumulations over the fronto-parietal area and at the vertex (Figs. 31 and 32). The patients often show mental changes, with signs of deterioration.

The Island of Reil is frequently seen in cases of advanced atrophy involving the Sylvian area (Figs. 7, 20, 29, and 30). It is usually associated with deficiencies in speech, especially if involved on the right side in left-handed individuals. In the ster-

coscope one may see the shrunken convolutions and this is evidence of the external hydrocephalic type (Fig. 30). Where no convolutional markings are seen and air is increased, especially with loss of the temporal lobe definition, a vascular thrombotic lesion is usually responsible for this finding (Figs. 30, 33, and 34).

SUMMARY

It has been our purpose to trace the path-

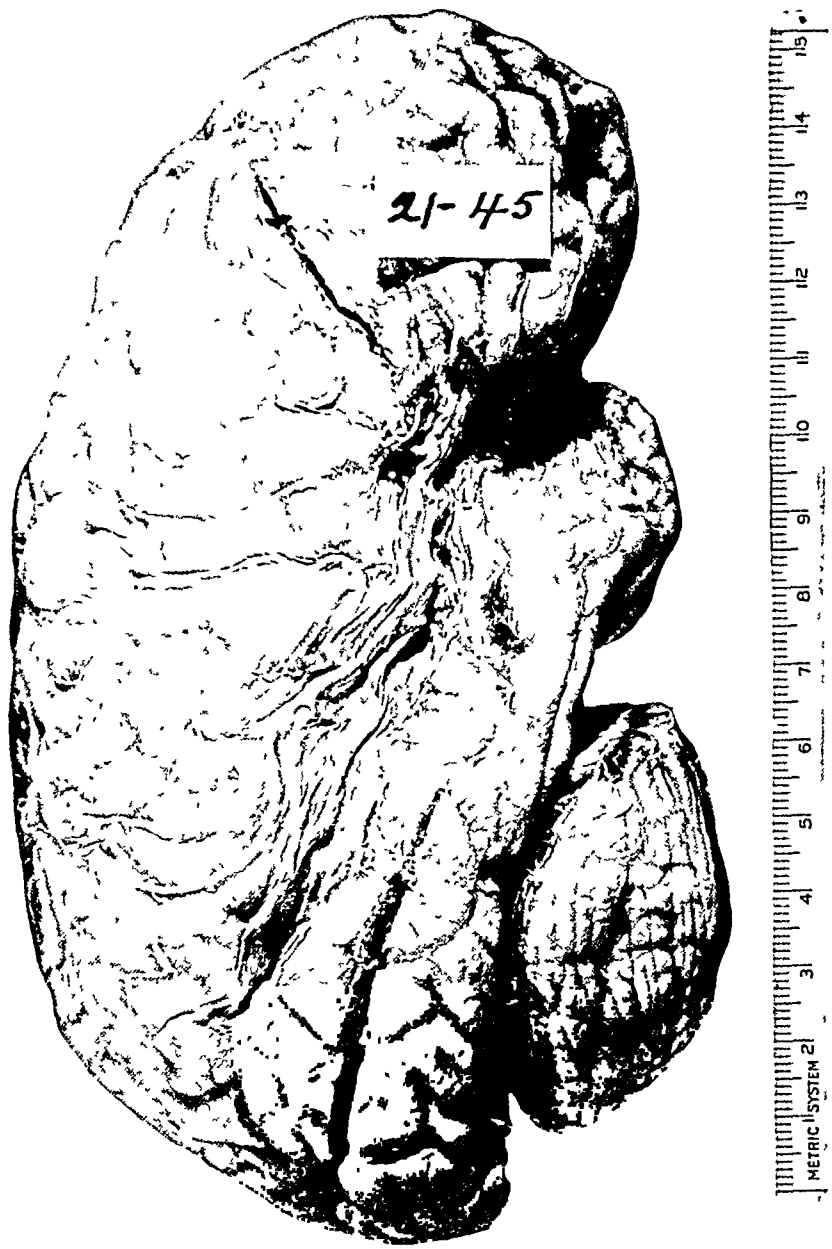


Fig 33 The appearance of a thrombotic lesion showing gross loss of brain structure and atrophy, including the temporal lobe Note in this type of lesion that there is no gross enlargement of the fluid pathways over the frontal lobe or even in the field of atrophy. The process is not similar to the obstructive arachnoiditis type although it may lead to extensive brain atrophy, which is characteristic of a general loss of cerebral architecture (Preparation by Dr N W. Winkelman.)

ways for cerebrospinal fluid circulation as we understand them at the present time, pointing out the roentgenological signifi- lesions exist along the course of these fluid pathways from their origin to their points of elimination.

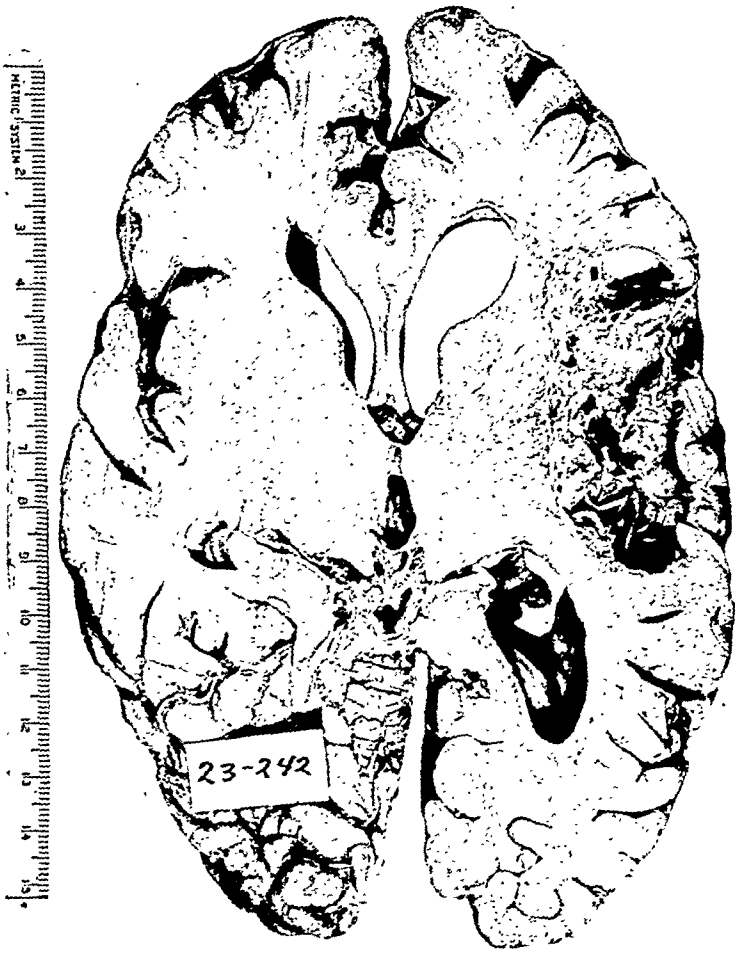


Fig. 34. Cross-section of a brain with a thrombotic lesion showing contracture of the brain substance, enlargement of the ventricles on the side of the lesion with sulci uninvolved in the neighborhood of the degeneration. Cortical atrophy is characterized by a loss of convolutional markings. (Preparation by Dr. N. W. Winkelman.)

cance as shown when cerebrospinal fluid is replaced by air.

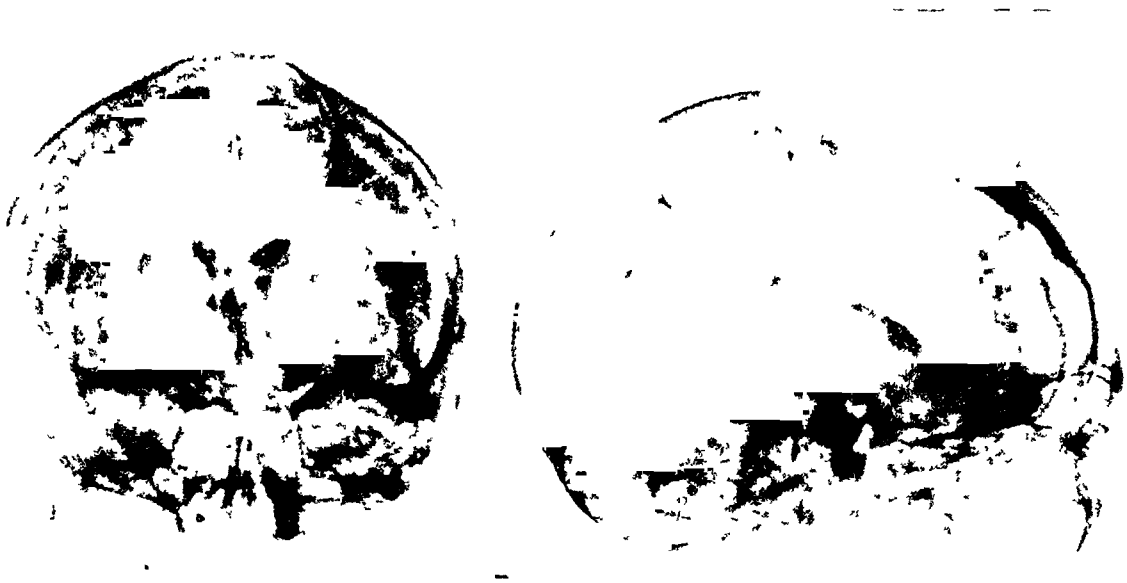
The interpretations of these air shadows are based upon the knowledge of neuro-anatomical relationships and the changes from the normal which occur when obstructive

The correlation of neurosurgical verification as well as neuropathological studies has justified the interpretations and mechanical considerations described above.

The indications, contra-indications, and diagnostic value of the procedure have been

discussed, and its definite use in many cases where focal signs are not clear-cut or obscure symptoms referable to the brain require clarification pointed out.

tion of an operative procedure to meet the actual requirements of the individual case. The risk in this type of case is undoubtedly higher than in any of the other groups, but



Figs. 35 (*left*) and 36 (*right*). Idiopathic epilepsy of three years' duration Note the increase of air in the midline and at the vertex, associated with beginning frontal pole atrophy

DISCUSSION

The procedure has demonstrated unsuspected gross lesions in the post-traumatic and birth injury groups, as pointed out by one of us (21). The cases of idiopathic and symptomatic epilepsy have shown gross atrophy in almost every case so far studied by the encephalogram, if symptoms have been present for a year or more (Figs. 35 and 36) Cases presenting mental deterioration (Figs 7, 25, 26, 29, and 30), dyskinesia (Figs 18, 19, and 20), chronic headache (Figs 37 and 38), vertigo, and post-traumatic neurosis (Figs 25 and 26) have revealed definite evidences of gross cerebral deformity as demonstrated by the encephalogram

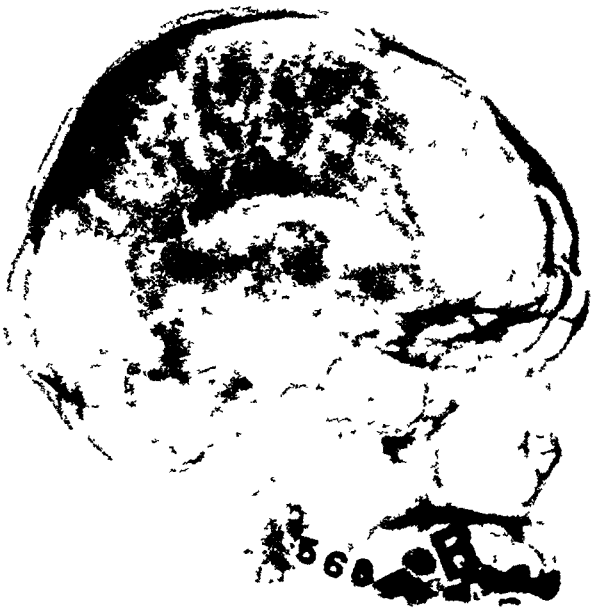
The need for careful selection of cases with signs of brain tumor has been pointed out, but the evidence obtained in *cerebral* tumors especially has made localization the more exact and determined the better selec-

it is our distinct impression that the risk assumed is less than that in ventriculography and no greater than lumbar puncture with withdrawal of fluid for diagnostic purposes

The gliomatous tumor frequently produces rapidly fatal symptoms spontaneously or with a slight disturbance of the pressure mechanism after a lumbar puncture, exploration, ventriculography, or encephalography.

A survey of 1,529 cases of encephalography in this country and abroad showed a mortality of 20 when followed to a three-months post-operative period (1 2 per cent). Three deaths were reported in cases of glioma, two in cerebellar tumors, five with internal hydrocephalus, and the remainder occurred in conditions such as premature infants, meningitis, alcoholic and paralytic patients, evidently poor risks Approximately 85 per cent of the deaths reported were from





Figs 37 *(left)* and 38 *(right)* Anteroposterior and lateral views of chronic case of cephalalgia simulating migraine, unknown origin Note increase in size of cortical air markings and evidence of chronic external hydrocephalus

foreign clinics, and it was evident that encephalography was used in cases where contra-indications existed or the condition of the patient did not warrant the procedure.

The value of encephalography as an important adjunct to diagnosis lies in its use where indications are clear-cut after careful study of the case from the neurological standpoint The technic of the procedure of air injection must be carried out with exacting regard for changes in intracranial pressure and proper manipulation of the patient during the procedure The roentgenological technic must be uniform and exact, to produce roentgenograms which are capable of interpretation The standardization of both procedures makes possible a basis for interpretation which has proved of distinct clinical value Only by such measures is it possible to correlate a series of cases and compare the findings with other groups as a basis for constructive analysis.

CONCLUSIONS

1. Encephalography has proved to be a diagnostic procedure of great importance when properly carried out.

2. The procedure of air injection must be carefully carried out by one familiar with the objects of the operation (drainage of the subarachnoid and ventricular spaces), with due regard to the importance of intracranial pressure changes and the indications and contra-indications presented in the cases selected.

3. The roentgenographic technic must be undertaken by a standardized and constant method so as to produce perfect roentgenograms which can be duplicated at subsequent examinations or can be utilized for making comparisons between different examinations.

4. The correct interpretation of the roentgenograms is possible only when the procedures both of air injection and

roentgenography have been perfectly carried out.

5. The diagnosis by the encephalographic findings requires an understanding of the neuro-anatomical relationships as seen in three dimensions and familiarity with gross neuropathological changes frequently encountered and giving rise to obstruction or distortion of the cerebrospinal fluid circulating pathways.

We wish to express our appreciation to those who have co-operated in making possible the presentation of these observations, especially to Dr. William G. Spiller and Dr. Eugene P. Pendergrass for clinical assistance; to Dr. Daniel J. McCarthy for the resources of his foundation, and to the neuropathological studies of Dr. N. W. Winkelman we are greatly indebted. Also to Dr. C. H. Frazier and Dr. M. Feldstein for the use of several illustrative cases.

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X-RAY ANALYSIS OF ATOMIC STRUCTURE

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1. INTRODUCTION

THE analysis of crystals by means of X-rays is familiar to most physicists and chemists. The analysis of crystals is effected principally by measuring the angular positions of an X-ray spectrum line of given wave length reflected in different orders by various planes of atoms in the crystal. By means of the powdered crystal method a single exposure enables us to measure the angular positions of all such reflections of a single wave length on a photographic film. The angular positions of the lines on the photograph must be measured accurately but the intensities of the various lines need be known only qualitatively. From the photograph, the arrangement and position of each atom in the crystal is determined.

However, if the intensities of the lines on a powdered crystal photograph are measured quantitatively, it is possible to obtain information as to the arrangement of the electrons in each of the atoms of which the crystal is composed, and thus the atom may be analyzed. Before proceeding with a description of the experiments, we shall give the theory of why it is that the arrangements of the electrons in the respective atoms of a crystal play a part in the intensities of a spectrum line as reflected in different orders.

2. THEORY

In crystal analysis it is assumed that the diffracting centers in a crystal lattice are the atoms. This, however, is not exactly true. It is more correct to say that the electrons of which the atoms are made up are the diffracting centers. If the electrons in an atom are arranged at different distances from the nucleus, then these electrons will not all exactly lie in a lattice plane of the

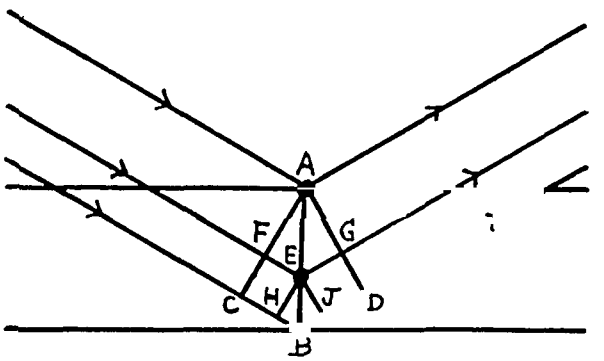


Fig. 1.

crystal even though the nucleus, which is at the center of the atom, does lie in a lattice plane. As a result of this atomic structure, therefore, the electrons will be most thickly concentrated in a lattice plane, but the concentration will not immediately drop to zero at points outside a lattice plane. The electron concentration at a point will probably fall off gradually as the distance of the point from a lattice plane increases.

Let us consider two lattice planes of a crystal as shown in Figure 1. Suppose an electron to be at A in the upper plane and a second electron to be at B in the lower plane, and suppose that the crystal is set at a grazing angle θ which satisfies the Bragg equation

$$n\lambda = 2d \sin \theta \qquad (1)$$

where λ is the wave length of the X-rays, n the order of reflection, and d the grating space, which in Figure 1 is equal to AB. In this position the path difference between the rays diffracted by A and B, respectively, is CB + BD and this must equal $n\lambda$. Suppose,

however, that the electron associated with the lower plane is at E, instead of at B, then the path difference between the rays diffracted by A and E, respectively, is FE + EG, which is less than nλ by a length

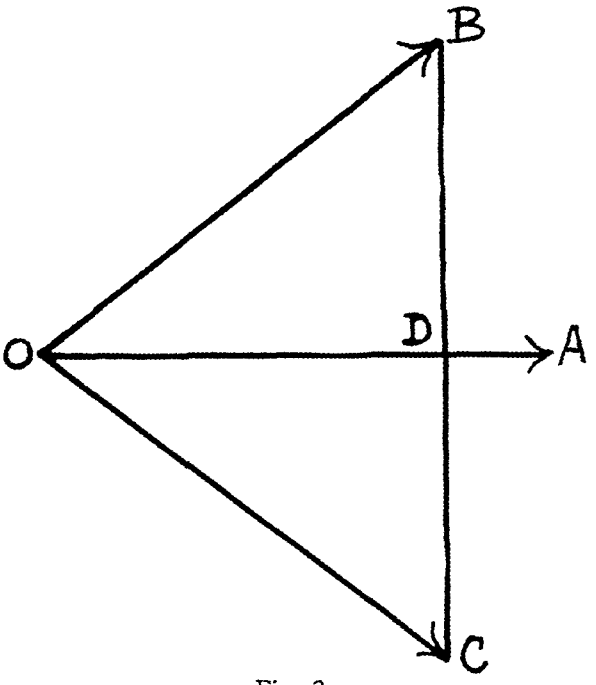


Fig. 2.

HB + BJ. Let BE = z, then HB + BJ = 2z sin θ, so that FE + EG = nλ — 2z sin θ. The diffracted ray from E will therefore be out of phase with the diffracted ray from A by an angle 4πz sin θ/λ. For each electron associated with the lower plane, as in Figure 1, but which is above the plane by a distance z, there will be on the average an electron similarly placed below the plane. Let us represent the amplitude of a wave diffracted by an electron exactly in the lower plane by a horizontal line OA in Figure 2, then the amplitude of the wave diffracted by an electron at E in Figure 1 will be represented by OB where the angle AOB is the phase angle 4πz sin θ/λ, and the amplitude of the wave diffracted by an electron at a distance z below the plane will be represented by OC where the angle AOC equals the angle AOB. The amplitude of the combined waves diffracted by these two electrons will be represented by 2 OD and this has a phase angle of zero. The amplitude of the combined waves then equals 2a cos (4πz sin θ/λ) where a is the amplitude OA. Hence on the average the amplitude per electron is half this amount, or a cos (4πz sin θ/λ). The effect of an electron at a distance z from a lattice plane is therefore the same as a fraction cos (4πz sin θ/λ) of an electron in a lattice plane. This fraction is called the amplitude factor for an electron. If, now, we add the amplitude factors for each of the electrons associated with a plane and divide this sum by the number of atoms associated with that plane, we obtain what is known as the atomic structure factor.

If the probability that an electron associated with a lattice plane is at a distance between z and z + dz from that plane is p(z)dz, then the average amplitude factor A for this electron is given by

$$A = \frac{\int p(z) \cos (4\pi z \sin \theta/\lambda) dz}{\int p(z) dz} \qquad (2)$$

where limits of the integrals are chosen so as to make the integral in the denominator equal to unity. We shall now consider two cases in which the amplitude factor may be easily calculated for the atom.

Electron on a Spherical Shell. A. H. Compton (1) has shown that if the electron is equally likely to be at any point on a spherical shell of radius b and if the center of the shell is in a lattice plane, then p(z) = 1/2b for the range —b<z<b, but p(z) = 0 for values of z outside this range. The average amplitude factor for the electron now becomes

$$A = \frac{1}{2b} \int_{-b}^{+b} \cos (4\pi z \sin \theta/\lambda) \, dz = \frac{\sin (4\pi b \sin \theta/\lambda)}{4\pi b \sin \theta/\lambda} \qquad (3)$$

This would be the value of the amplitude factor for an electron moving in a Bohr cir-

cular orbit whose plane is equally likely to be oriented in any direction. If there are electrons of different kinds, such as K, L, M, in an atom, the sum of the amplitude factors for each electron in the atom is called the true atomic structure factor f, and hence in the case of the electrons being on shells we have

$$f = \sum_r \frac{n_r \sin(4\pi b_r \sin\theta/\lambda)}{4\pi b_r \sin\theta/\lambda} \qquad (4)$$

where b_r is the radius of the r^{th} shell and n_r is the number of electrons in the r^{th} shell. The right side of Eq. (4) may have a negative value and it is difficult to obtain a negative value for f experimentally, as will be seen later. In recent years, however, physicists have abandoned the Bohr model and have tended to adopt the wave-mechanical model of Schrödinger (2), which we shall now consider.

Schrödinger's Model of the Hydrogen Atom. In this model the electron is neither at a fixed distance from the nucleus nor does it revolve about the nucleus in any particular orbit. Schrödinger's first picture was that the electron was replaced by a continuous distribution of electricity whose density varied with the distance from the nucleus. In the case of the normal hydrogen atom the charge density, ρ, was given by

$$\rho = (e/\pi a_o^3)\exp(-2r/a_o) \qquad (5)$$

where r is the distance from the nucleus and $a_o = 0.53$ Ångström is the radius of the first orbit in the Bohr model. According to more recent ideas ρ in Eq. (5) is not the charge density but a probability function, such that the chance of an electron being in a small volume dV at a distance r from the nucleus is $(\rho/e)dV$ where ρ is given by Eq. (5). Using this interpretation of ρ, the probability that an electron is between two parallel planes at distances z and $z+dz$ from the nucleus, respectively, works out to be

$$\rho(z)dz = (1/2a_o)\exp(-2z/a_o)dz \qquad (6)$$

for positive values of z. In Eq. (6), a_o is to be considered as a parameter distinguishing the various electrons in the atom of a crystal. There is a similar expression with the sign of z changed for negative values of z. Substituting this in Eq. (2) and making the limits of the integrals $\pm\infty$ we obtain

$$A = 1/(1 + 4\pi^2 a_o^2 \sin^2\theta/\lambda^2) \qquad (7)$$

Comparing Eq. (3) with Eq. (7), we notice that whereas A may assume negative values in the former case, it never does so in the latter case.

Effect of Temperature. So far we have considered the simple case where the centers of the atoms are on lattice planes. However, each atom as a whole is subject to thermal agitation and this agitation increases with the temperature of the crystal. The centers of the atoms therefore tend to depart more and more from the lattice planes. Let us consider the simple case where, except for the thermal agitation, the electrons lie in lattice planes. Suppose the electrons to be held in place by elastic forces so that, if an electron is displaced a distance z from a lattice plane, the force of restitution is γz where γ is a constant. If a is the component of the amplitude of thermal vibration of the electron perpendicular to a lattice plane, then $\gamma a^2/2$ is the energy of vibration associated with this direction. According to Boltzman's principle the probability of an electron having an energy between w and $w+dw$ is proportional to $\exp(-w/kT)dw$. Hence the probability of an electron having a component amplitude of thermal vibration between a and $a+da$ is proportional to $a\exp(-\gamma a^2/2kT)\,da$. The probability that an electron whose amplitude of vibration is a is between distances z and $z+dz$ from a lattice plane is $dz/(\pi\sqrt{a^2-z^2})$ for $z<a$ and zero for $z>a$. The probability that an electron whose amplitude of vibration has any value greater

than z is between distances z and $z + dz$ from a lattice plane is $\rho(z)dz$ where

$$\rho(z) = \text{const} \int_z^\infty \frac{a \exp(-\gamma a^2/2kT)}{\pi \sqrt{a^2 - x^2}} \, da$$

or

$$\rho(z) = \sqrt{\gamma/2\pi kt} \exp(-\gamma z^2/2kT) \quad (8)$$

Finally the average amplitude factor for the electron is

$$A = (\gamma/2\pi kT) \int_{-\infty}^{\infty} \exp(-\gamma z^2/2kT) \cos(4\pi z \sin\theta/\lambda) dz = \exp(-B \sin^2\theta/\lambda^2) \quad (9)$$

where $B = 8\pi^2 kT/\gamma$. This is the form as obtained by Debye (3). It is seen that A depends upon the absolute temperature and upon the elastic constants of the body through γ.

We do not usually think of the thermal vibrations of the electrons which constitute an atom but rather of the vibrations of the atom as a whole. It can be shown that when an atom whose electrons are arranged on a sphere of radius b vibrates thermally, carrying its electrons with it, the average amplitude factor for each electron is

$$A = \frac{\sin(4\pi b \sin\theta/\lambda)}{4\pi b \sin\theta} \exp(-B \sin^2\theta/\lambda^2) \quad (10)$$

In general, the atomic structure factor F consists of two factors—the true atomic structure factor, which is usually represented by f, and the temperature factor, so that

$$F = f \exp(-B \sin^2\theta/\lambda^2) \quad (11)$$

3. EXPERIMENTAL METHODS

W. L. Bragg (4) and his pupils have developed a technic for obtaining what is known as the integrated reflection. A crystal is rotated past the reflection angle θ with an angular speed ω. If the ionization produced in a chamber by the reflected X-rays during the time of turning from one position of no reflection, through the position of reflection to a second position of no reflection, is represented by E and the ionization produced by the primary X-rays in unit time is represented by I, then the integrated reflection at this order of reflection is given by $E\omega/I$.

According to C. G. Darwin (5), the integrated intensity is given by

$$\frac{E\omega}{I} = \frac{N^2 e^4 F^2 \lambda^2}{2m^2 c^4 \sin 2\theta} \cdot \frac{(1 + \cos^2 2\theta)}{\mu} \quad (12)$$

where N is the number of molecules per cubic centimeter of the crystal, θ is the Bragg angle of reflection, λ is the wave length of the X-rays used, e and m are the charge and mass of the electron, respectively, c the velocity of light (inserted because e is in electrostatic units), μ the linear absorption coefficient of the X-rays in the crystal and F is a measure of the diffracting power of the atom. F is also known as the atomic structure factor. All the quantities in Eq. (12) can be measured or are known except F, so that Eq. (12) can be used to determine F. It should, however, be noted that μ is not the ordinary linear coefficient of absorption, because W. H. Bragg (6) has shown that when a crystal is in a position to reflect X-rays its absorption coefficient is abnormally high. The increase in the ordinary absorption coefficient is termed the extinction coefficient by W. L. Bragg (4). Methods for the determination of the extinction coefficient are described in the papers of W. L. Bragg and also in Chapter V of A. H. Compton's "X-rays and Electrons," and will not be further discussed here.

When the experimental values of F as obtained from Eq. (12) are plotted again $\sin\theta$, it is found in the case of rocksalt that the points representing the F values, as they are called in the literature, fall upon two curves, I and II, as shown in Figure 3. The points which fall upon the upper curve are obtained from the integrated reflections of all orders from the even planes and of even orders from odd planes, while the points which fall upon the lower curve are obtained from the integrated reflections of odd or-

ders from the odd planes. In rocksalt, an even plane consists of both sodium and chlorine atoms, while an odd plane consists either of sodium atoms alone or of chlorine atoms alone. In reflections of odd or-

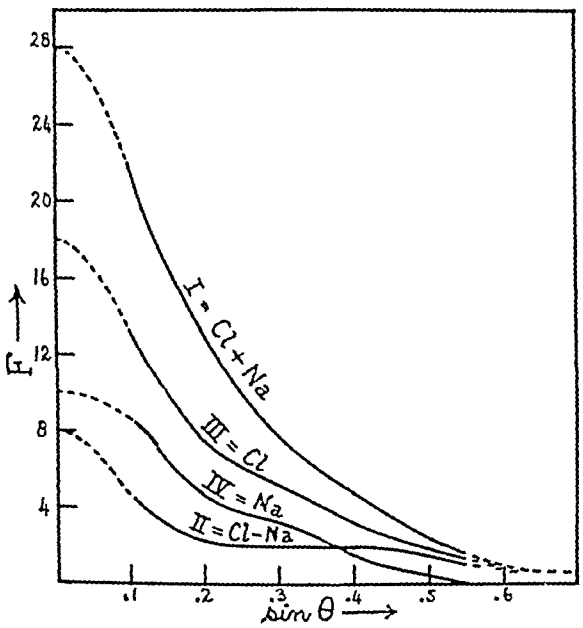


Fig. 3.

der from odd planes, the rays diffracted by the sodium planes are in opposite phase to the rays diffracted by the intermediate chlorine planes and Curve II of Figure 3 is, therefore, called the (Cl — Na) curve. Because the sodium and chlorine atoms cooperate in the even order reflections, Curve I is called the (Cl + Na) curve. Obviously, if we have the F values for (Cl + Na) and for (Cl — Na), we can obtain the curves for the F values of Cl and Na alone by taking respectively half the sum and half the difference of the ordinates of the (Cl + Na) and (Cl — Na) curves. The F curves for Cl and Na alone are shown as Curves III and IV, respectively, in Figure 3. The full portions of the curves in Figure 3 are obtained from experimental values of the integrated intensity, while the broken portions are extrapolations.

Havighurst (7) and Bearden (8) have obtained F values from the intensities of X-rays reflected in different orders and from different planes of powdered crystals. The powdered crystal method has the advantage over Bragg's single crystal method in that when the particles of the powdered crystal are small enough no correction for the extinction coefficient is necessary.

4. INTERPRETATION OF THE EXPERIMENTAL F VALUES

Having obtained the experimental F values for the atoms of a crystal, it is possible to calculate the arrangement of electrons in an atom of the crystal. Two methods are available to us. In the first method, a model of the atom is assumed in which there are certain disposable parameters, such as the radii of Bohr orbits. The f value of the model is determined and then multiplied by the Debye temperature factor. If the values of the parameters can be chosen so that the curve for theoretical F values for different values agrees with the experimental F curve, the problem is solved. If the theoretical and experimental F curves do not agree, then another trial must be made. This method is thus indirect and unsatisfactory. W. Duane (9) and, later, A. H. Compton (10) have developed a second method of unravelling the structure of the atom. This method is analytical and direct. It is known as the Fourier analysis method because it makes use of the same mathematical principle as used in analyzing a periodic motion into its constituent simple harmonic motions. Two formulas are used in this method. The first formula enables us to calculate the number of electrons between planes at distances z and z + dz from a lattice plane in terms of the F values. This number is P(z) dz where

$$P(z) = Z/D + (2/D) \sum_n F_n \cos(2\pi nz/D) \qquad (13)$$

where Z is the number of electrons in the

atom, D is the grating space, and F_n is the atomic structure factor calculated for the n^{th} order reflection from the set of planes whose grating space is D. The disadvantage of Eq. (13) is that the value of Z cannot be obtained from the X-ray analysis. The second formula enables us to calculate the number of electrons between spheres of radii r and r + dr from a lattice point. This number is U(r) dr where

$$U(r) = (8\pi r/D^2) \sum_n nF_n \sin(2\pi nr/D) \qquad (14)$$

A set of F values is shown in Table I.

TABLE I

F VALUES FOR THE ATOMS OF ROCKSALT
D = 3.25 Ångströms
sinθ for first order = 0.109

n	F_n		n	F_n	
	Cl	Na		Cl	Na
1	13.60	8.80	5	2.10	0.10
2	7.84	5.46	6	1.15	0.00
3	5.15	3.05	7	0.31	
4	3.40	0.72			

From the F values, shown in Table I, the radial distributions, U(r), of the electrons can be found for the chlorine and sodium atoms in rocksalt. These are shown in Figure 4. The position of the maximum of each of the humps gives the distance of each different group of electrons from the center of the atom, while the area under each of the humps gives the numbers of the electrons in the respective groups. Thus in the sodium atom there are 8 (K + L) electrons at 0.35 Ångström and 2L electrons at 0.85 Ångström from the average center of the atom. The term "average center" is used because the atom is subject to thermal vibrations. The K and some of the L electrons are merged together because of the thermal vibrations. If the constant B in the Debye temperature factor, $\exp(-B\sin^2\theta/\lambda^2)$, can be determined, the true atomic structure factor f can be obtained by dividing F by the Debye factor. Substituting these f values in Eq. (13) in place of the F values, a radial distribution or U curve can be obtained for an atom which is not subject to thermal

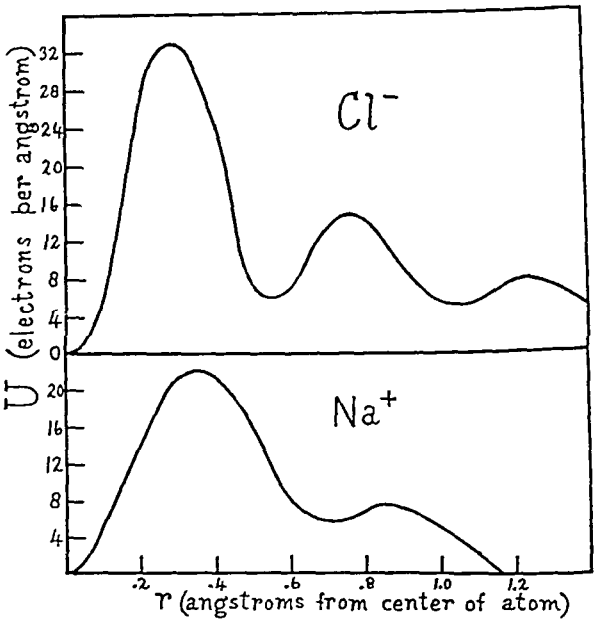


Fig. 4.

vibrations. Such a procedure is usually not followed because of the uncertainty of the exact value of B in the temperature factor. In Section 2 of this article we obtained B in terms of γ for a simple case. Debye (3) and Waller (11) have considered the temperature factor and have obtained B in terms of the "characteristic temperature" of the crystal. However, Waller's formula for B gives B twice the value which is obtained from Debye's formula. Hence, experiments on the temperature factor are necessary and we now proceed to consider these.

5. EXPERIMENTS ON THE TEMPERATURE EFFECT

As early as 1914 W. H. and W. L. Bragg (12) found that the intensity of X-rays reflected by rocksalt decreased with rise of temperature in a way which agreed quali-

tatively with Debye's formula. Later, in 1922, Backhurst (13) attacked the problem again, using temperatures ranging from 15° C. to 950° C. In Backhurst's experiments the crystal was placed inside an electric heater, furnished with mica windows suitably placed to allow of the ingress and egress of the X-rays. The space inside the heater and surrounding the crystal was filled with a nitrogen atmosphere and the temperature was measured by a thermocouple. Backhurst used crystals of aluminum, carborundum, graphite, diamond, and ruby. For the first three a decrease in intensity with increase of temperature was observed in qualitative agreement with Debye's formula. No decrease in intensity was found for diamond, but diamond has a high characteristic temperature and Debye's formula gives a very small change in this case for the temperatures used. Ruby was somewhat anomalous but again the effect was qualitatively in agreement with the formula. In 1924, Collins (14) applied the powdered crystal method to aluminum foil, the wave length of the X-rays being 0.71 Ångström. The intensity of the rays reflected from the (100), (110), (111), and (311) planes was measured for temperatures of 80°, 310°, and 600° C. As the temperature increased the reflection maxima appeared at smaller angles due to expansion of the crystal. This effect was also found by the previous experimenters. Collins found a decrease in intensity with rise of temperature. The decrease was found to be greater than that given by Debye's formula. The effect of temperature as we have seen in Section 2 of this paper is to cause the crystal planes to become more diffuse and less distinct. Collins' results therefore show that the planes lose their distinctness more rapidly with rise of temperature than according to Debye's theory. However, the decrease will be more rapid according to Waller's formula and so Collins' results are more in accord with this later formula.

In 1925, James (15) found that the decrease in intensity for rocksalt in the temperature range 17° C. to 627° C. was much greater than Debye's formula predicted but was in accord with Waller's formula. In 1926, James (16) extended the investigation to temperatures below room temperature and down to approximately liquid air temperatures. In these experiments the crystal was held in a stout brass holder, suspended by means of a hard rubber rod just above the liquid air surface in a Dewar flask. The Dewar flask was made of borosilicate glass which was so thin as to transmit 70 per cent of the radiation. By decreasing the temperature the intensity of the higher orders of reflection increases considerably. For example, the fifth order spectrum was nearly 3.4 times as intense at —185° C. as at room temperature. The results again agree more closely with Waller's formula than with Debye's. For high temperatures the curve falls off too rapidly for either theory, and in all probability this denotes that the elastic properties of the crystal are here changing as the melting point is approached. For low temperatures the intensities are somewhat lower than Waller's theory requires.

In 1927, James and Firth (17) conceived the idea of testing the reflections from both the odd and even planes and of obtaining F curves for different temperatures. They found that there was a different temperature factor for the (Cl + Na) and (Cl — Na) curves. They were then led to postulate different temperature factors for the chlorine and sodium atoms. Instead of the atomic structure factor being given by Eq. (11), it is given by

$$F = f_1 \exp(-B_1 \sin\theta^2/\lambda^2) \pm f_2 \exp(-B_2 \sin^2\theta/\lambda^2) \quad (15)$$

where f_1 and B_1 relate to chlorine and f_2 and B_2 to sodium. The plus sign is used for the

(Cl + Na) curve and the minus sign for the (Cl — Na) curve.

James and Firth use Eq. (13) and arrive at the distribution of electrons between planes. These distribution curves are obtained for various temperatures and an extrapolation is made to absolute zero. From the way the distribution curve varies with temperature James and Firth find the average amplitude of the thermal vibrations to be 0.20 and 0.23 Ångström for the chlorine and sodium atoms, respectively, when the temperature of the rocksalt is 17° C. The average amplitude of the thermal vibrations of both kinds of atoms at 627° C. is 0.58 Ångström. Thus by means of X-ray analysis we can, as it were, watch the increase of the amplitude of thermal vibration of the atoms as the temperature increases.

A complementary problem to that of the intensity of X-rays regularly reflected from crystals is that of the intensity of diffusely scattered X-rays. In addition to the reflected X-rays which are given by Bragg's law, there is diffuse scattering in all directions from a crystal. According to Debye's theory (3) the intensity of the diffuse scattering from a crystal increases with the temperature at the same time as the intensity of regular reflection decreases. Debye's theory requires that the intensity of the diffuse scattering shall be proportional to $[1—\exp(—B \sin^2\theta/\lambda^2)]$ where θ is now one-half the angle of scattering. In 1922, Jauncey (18) made experiments on the diffuse scattering from rocksalt and calcite at temperatures of 17° C. and 295° C. Jauncey found no increase in the intensity of the X-rays diffusely scattered by calcite, and only a small, and possibly no, increase in the case of rocksalt. These results are definitely not in accord with the Debye theory. In Debye's theory, the effect of an increase in temperature is to produce a more random distribution of the electrons. The Thomson (19) theory of the diffuse scattering of X-rays assumes a random distribution of electrons in the scattering substance. This theory gives a formula which is in fairly good agreement with the observed intensity of scattered X-rays from amorphous substances as shown by Barkla (20) and others. It therefore seems reasonable to suppose that as a crystal approaches an amorphous body, at least as far as its electron distribution is concerned, the crystal would scatter more like an amorphous substance, whereas the fact is that the temperature factor for diffuse scattering is either zero or very much smaller than the factor as derived by Debye. However, the diffusely scattered X-rays from crystals exhibit the Compton effect, that is, a change of wave length on scattering. The Compton effect is not taken into account in the Debye theory and this is one reason for the lack of agreement between theory and experiment.

It should be noted that Debye obtains two formulas for B in Eq. (11). The one formula is for the case where zero point energy is assumed and the other formula for the case of no zero point energy. Planck introduced the idea of zero point energy in his quantum theory of radiation. Zero point energy is the energy still existing in an oscillator at absolute zero. Its value is half a quantum of energy per degree of freedom. Neither of Debye's formulas agree with experimental results for diffuse scattering although they agree qualitatively with the results for regular reflection.

6. THE STRUCTURE OF THE ATOM

In 1928, James, Waller, and Hartree (21) attacked the problem of the interpretation of the experimental F curves from the point of view of Schrödinger's theory of the distribution of electrons in the atom. Their method was to devise a Schrödinger model similar to that described for hydrogen in Section 2 of this paper, although the

model for an atom like chlorine or sodium is much more complicated than the model for hydrogen. They were able to devise approximate methods for constructing the models and then to calculate the f curves for model atoms in a crystal. These f curves are then multiplied by their respective temperature factors as in Eq. (15), and theoretical F values obtained. These theoretical F curves were found to agree with the experimental F curves. They prefer this method of attack to the Fourier analysis method because of the uncertainty of the F values for the higher orders of reflection. The U (*i.e.*, radial distribution) curves for Na^+ and Cl^- are given in their paper. The Na^+ curve has humps at about 0.05 and 0.33 Ångström and the Cl^- curve humps at 0.04, 0.18, and 0.85 Ångström from the center of the atom. These U curves are for atoms which have no thermal vibrations. It is seen, therefore, that although in recent physical theory the idea of the electrons of an atom being located on definite shells has been abandoned, yet the electrons do tend to congregate at certain distances from the center of the atom.

James, Waller, and Hartree found it necessary to assume some heat motion at absolute zero, the amount of energy required being that of Planck's zero point energy. Combining this assumption with the assumption of Schrödinger distribution, they obtained better agreement with the experimental F values. Also they obtained better agreement when they assumed chlorine and sodium ions than when they assumed neutral atoms. It seems, therefore, that the structures of the atoms in rocksalt have been completely evaluated.

In 1928 James and Brindley (22) obtained experimental F values for sylvine (KCl) and applied the method of James, Waller, and Hartree in order to obtain the electron distributions in potassium and chlorine. It was, as in the case of rocksalt, found necessary to assume zero point energy and also to assume that the potassium and chlorine exist as the ions K^+ and Cl^-. The radial electron distribution of K^+ has humps at about 0.04, 0.15, and 0.62 Ångström. The humps for Cl^- occur at about 0.04, 0.17, and 0.78 Ångström. The average amplitudes of the thermal vibrations of the potassium and chlorine atoms are equal at the same temperature and are 0.15 and 0.26 Ångström at —187° C. and 17° C., respectively. In the case of rocksalt the amplitudes are different for the different atoms but in sylvine the masses of the potassium and chlorine atoms are so nearly equal that there is no difference between the amplitudes at the same temperature.

In 1929 James, Brindley, and Wood (23) obtained experimental F values for X-rays of wave length 0.71 Ångström reflected from aluminum crystals. The importance of this experiment is that, whereas rocksalt and sylvine both consist of two kinds of atoms, a crystal of aluminum consists of only one kind of atom. Both Debye's theory and Waller's modification (11) of Debye's theory are applicable only to cubic crystals of one kind of atom. James, Brindley, and Wood conducted their experiments at —187° C. and 17° C. The experimental temperature factor comes out to be that given by Waller's formula for zero point energy. The average amplitude of thermal vibration is found to be 0.11 Ångström at —187° C. and 0.17 Ångström at 17° C. Since aluminum is a conductor of electricity it is assumed that the crystal consists of free electrons and a lattice of ionized atoms. It was found unnecessary to take account of the free electrons in calculating the theoretical F values based on the Schrödinger distribution of the electrons in the atom. However, the theoretical F values for the ions Al^{+1}, Al^{+2}, and Al^{+3} were found to give curves which agreed within experimental error with the experimental F curve

and hence no determination of the state of ionization of the aluminum atoms was possible. The U curve for Al^{+2} shows humps at about 0.05 and 0.25 Ångström from the center of the atom.

The Schrödinger models for Na^{+}, K^{+}, Al^{+2}, and Cl^{-}, which give F values agreeing with the experimental F values, all contain 2 K electrons and 8 L electrons. K and L electrons on the Schrödinger theory are electrons which are most probably at distances from the center of the atom respectively equal to the abscissæ of the first and second humps of a U curve.

The results reported in this section are collected in Table II.

TABLE II

Crystal	Atom	Average amplitude of thermal vibrations (Ångströms)			Most probable distances of electrons from center of atom (Ångströms)		
		—187°C.	17°C.	627°C.	K	L	M
Rocksalt	Na^{+}		0.23	0.58	0.05	0.33	
	Cl^{-}		0.20	0.58	0.04	0.18	0.85
Sylvine	K^{+}	0.15	0.26		0.04	0.15	0.62
	Cl^{-}	0.15	0.26		0.04	0.17	0.78
Aluminum	Al^{+2}	0.11	0.17		0.05	0.25	

From Eqs. (2), (7), and (11), it is seen that the atomic structure factor is a function of $\sin\theta/\lambda$. Since $n\lambda = 2d\sin\theta$ we see that the F values for a given crystal are a function of the order of reflection alone and are not a function of the wave length. Hence all F curves plotted against $\sin\theta/\lambda$ for rocksalt should be the same for different wave lengths reflected from the crystal. So far as rocksalt is concerned, W. L. Bragg, James and others have used both Rh Kα and Mo Kα X-rays and no difference in the F curves as plotted against $\sin\theta/\lambda$ has appeared. However, Miss Armstrong (24) reflected Mo Kα and Cu Kα rays from copper and iron powders. The F values for the Cu Kα rays reflected in a given order from copper were less than the F values for Mo Kα rays reflected in the same order. A similar result but with less difference between corresponding F values was found for the rays reflected from iron. It should be mentioned that while both the Mo Kα and Cu Kα rays excite the K spectrum of iron, it is only the Mo Kα rays which excite the K spectrum of copper. It seems then that F is a function of $\sin\theta/\lambda$ alone only so long as the X-rays used are not near a critical absorption wave length of the crystal.

Miss Armstrong (25), using the powdered crystal method, subjected diamond to X-ray analysis. She found a (222) reflection (this notation means a second order reflection from the (111) planes) from diamond. This reflection should not appear if diamond has exactly the structure usually assigned to it and consists of carbon atoms which are all alike. According to Miss Armstrong, this reflection might occur if the carbon atoms are of two kinds with different F values, or if adjacent carbon atoms shared electrons between them in such a way as to provide scattering centers on the line joining them. It seems, however, that neither explanation is entirely compatible with the experimental results.

It has long been felt that the F values for a crystal of a magnetic substance should change when the crystal is magnetized. Stearns (26), using a sensitive null method, in which two crystals and two ionization chambers were employed, was unable to detect any change in intensity when one crystal was magnetized, and hence found no change in the F values. The lack of change

in the F values means that the electron structure of an atom of a magnetic crystal is unchanged when the crystal is magnetized. It appears from this experiment that the ultimate magnet must be the spinning electron.

Wyckoff (27), in discussing Miss Armstrong's finding (24) that F is not a function of $\sin\theta/\lambda$ alone for a given crystal, points out that her conclusions are dependent upon the correctness of the measured absorption coefficients, since, as in Eq. (12), the calculation of the F values from the experimental intensities involves a knowledge of the absorption coefficient of the X-rays in the crystal. Accordingly Wyckoff used a crystal of NiO so as to avoid such an uncertainty, since the F values of two kinds of atoms in the same crystal can be obtained. The F curves for the oxygen atoms in the crystal when plotted against $\sin\theta/\lambda$ were found to be very nearly identical for the three wave lengths of Mo, Cu, and Ni $K\alpha$ X-rays. On the other hand, relatively large differences were found to exist in the F curves for the nickel atoms. The variation in the F curves is thus a real effect and is not due to the use of an incorrect value of the absorption coefficient.

7. CONCLUDING REMARKS

Before bringing this paper to a close, it should be mentioned that a few years ago, before Schrödinger's wave mechanics had been applied to the problem of the reflection of X-rays from crystals, it seemed that some account should be taken of the Compton effect. Up till that time it had been impossible to construct Bohr models of the sodium or chlorine atoms which would give F values in agreement with the experimental F values for rocksalt. Williams (28) and Jauncey (29) used Bohr models for the atoms of the crystal and by modifying the theory so as to take account of the Compton effect were able to arrive at theoretical F values which agreed better with the experimental F values than had the previous theoretical F values. In the Compton effect, when X-rays of a given wave length are scattered, two lines appear in the spectrum of the scattered rays—one line, called the unmodified line, having the same wave length as that of the primary rays, and the second line, called the modified line, having a longer wave length than the primary rays. The X-rays which constitute the modified rays are not coherent with the primary rays and hence cannot take part in interference phenomena, of which reflection of X-rays from crystals is an example. However, Waller (30), Wentzel (31), and Waller and Hartree (32) have shown on the basis of wave mechanics that the coherent scattering by an atom may be calculated from its Schrödinger electron distribution by supposing the electron in this distribution to scatter according to the classical theory and then taking into account the interference between X-rays scattered from different parts of the atom. Since James, Waller, and Hartree have been able to devise Schrödinger atoms which give F values in agreement with the experimental values, it seems that the Compton effect does not need to be taken into account when such models of the atoms of a crystal are used.

In closing, it may be stated that the evidence obtained from experiments on the intensity of reflected X-rays from crystals strongly supports the Schrödinger theory of the electron distribution in the atoms of crystals.

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WHEN HAS VISCEROPTOSIS CLINICAL SIGNIFICANCE?[1]

By D. S. BEILIN, M.D., Roentgenologist, Augustana Hospital, Chicago, Illinois

THIS paper is based on a study of hospital- and out-patients sent to the Department of Roentgenology for a diagnosis of gastro-intestinal pathology. Twenty per cent of the patients examined have clinical visceroptosis. The responsibility for the diagnosis rests upon the roentgenologist.

Visceroptosis has undoubtedly occurred since man assumed the upright position. In 1833 Glénard published his thesis on this subject, since which time visceroptosis has been called "Glénard's disease." It has been defined as a prolapse or falling or dropping of the viscera. When it involves the stomach it is termed "gastroptosis"; the intestines, "enteroptosis"; the colon, "coloptosis"; the liver, "hepatoptosis," and the kidneys, "nephroptosis."

The subject of visceroptosis has been studied for many years, but it is only since the discovery of the X-ray and the use of the opaque meal that exact observations have been made. At the present time there is much difference of opinion as to the degree of prolapse which is to be regarded as pathologic. Only the two most common manifestations of visceroptosis, namely, gastroptosis and coloptosis, will be considered in this paper.

It should be emphasized that there is a marked difference between anatomic and clinical visceroptosis. In the former, the low position of the stomach or colon does not interfere with physiologic function; whereas, in the latter the dropped or prolapsed position of the organ results in a perversion of physiologic function which gives rise to symptoms. Therefore, visceroptosis should not be viewed from the anatomic viewpoint. When clinical symptoms arise as a result of physiologic malfunction in a visceroptotic individual in whom organic disease has been excluded, then, and then only, has visceroptosis clinical significance.

Gastroptosis, often called *falling* or *dropping of the stomach,* results from a relaxation or a stretching of the mesenteric or peritoneal attachments. Clinical gastroptosis often follows where there has been emaciation and relaxation of the abdominal muscles, as well as absorption of fat from the lesser omentum and the gastrohepatic and gastrocolic ligaments. Gastroptosis is almost always acquired; some individuals inherit a constitutional predisposition toward it. The condition is more prevalent in the female, the ratio in our series being 4 to 1. The condition occurs in individuals from 20 to 70 years of age; 80 per cent of cases occur in the age period from 20 to 50.

In clinical gastroptosis the stomach is usually elongated, the greater curvature being considerably below the inter-iliac line, often resting on the pelvic floor. There is often an associated atony. The cardiac portion of the stomach is never displaced downward, whereas the pyloric portion often occupies a level below the normal. The most common position of the lowest part of the greater curvature in normal individuals, examined in the erect posture, was in the zone from 2 to 7 centimeters below the inter-iliac line. The average position of the lowest part of the lesser curvature was between the inter-iliac line and a point 5 centimeters above it, the pylorus being between 2.5 and 5 centimeters above the line. In individuals with the clinical type of gastroptosis, the average distance of the greater curvature below the inter-iliac line was 9 centimeters, whereas the average distance of the pylorus above the line was 2.9 centimeters. It is obvious that, anatomically, the two types of

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individuals show only slight variation. It is important to emphasize that the presence and the severity of the symptoms depend on the perversion of function of the organ or organs involved and not upon their position.

Coloptosis, or so-called *dropping* or *prolapse of the colon,* is likewise a result of relaxation of the ligaments which normally hold the colon in place. There is often a failure or atony of the abdominal musculature maintaining intra-abdominal tension. Coloptosis is usually right-sided. The region of the hepatic flexure, as well as the transverse portion, usually reveals sagging. Very often there is a dropping of the central portion of the transverse colon as far as the pelvic floor.

In the writer's series of 100 cases of clinical gastroptosis and coloptosis in which organic disease was excluded, the following conditions in respect to frequency were the predisposing causes: pregnancy, influenza, tuberculosis, colitis, pneumonia, pyelitis, thyrotoxicosis, and syphilis. As a result of the above conditions there was a loss of fat, relaxation of the ligaments as well as faulty tone of the abdominal muscles, associated with decreased intra-abdominal pressure.

The cardinal symptoms of clinical gastroptosis are pain or distress or a drag in the epigastrium, which occurs usually immediately after eating, when the patient is in the upright position. This was present in 95 per cent of the cases, nausea in 43 per cent, vomiting in 42 per cent, loss of weight in 39 per cent, and gas in 33 per cent. There was relief of symptoms in all cases when the patient was kept in the Trendelenburg position. The cardinal symptoms of coloptosis are distress or drag or a pain, more particularly at the sites of the splenic and hepatic flexures; very often soreness or pain at the region of the cecum. These symptoms are usually manifest when the patient is in the upright position, with relief of symptoms when the patient is in the Trendelenburg position.

Symptoms of lesser frequency in gastroptosis and coloptosis are migraine, vertigo, backache, fever, exhaustion, dyspnea, and particularly neurasthenia. The symptoms are due to a drag on the mesentery, with its resultant irritation to the sympathetics and vagus, and to duodenal stasis causing toxic absorption.

The responsibility for the diagnosis of clinical gastroptosis and coloptosis is almost entirely dependent upon the roentgenologist, as a careful objective exclusion diagnosis of organic disease of the gastro-intestinal tract must be made. The diagnosis of this condition is purely a fluoroscopic procedure. With the patient in the upright position behind the fluoroscopic screen, the stomach filled with the barium meal, he manifests the symptoms of which complaint is usually made. The cardinal diagnostic sign is that the symptoms are usually relieved when the stomach is elevated manually, and almost immediately entirely relieved when the patient is placed in the Trendelenburg position, using a tilt table. The symptoms recur when the patient is placed in the upright position and again disappear when he is placed in the Trendelenburg position.

Organic disease must be excluded. The heart and lungs are examined fluoroscopically and radiographically; the stomach, duodenum, jejunum, ileum, colon, pancreas and the appendix are excluded fluoroscopically; the genito-urinary and biliary tracts are excluded radiographically, when indicated.

It is important to bear in mind that organic disease is occasionally associated with clinical visceroptosis, and, when present, it is essential that both conditions be properly evaluated in order to obtain the best clinical results. Fifty-one per cent of the patients studied have had previous abdominal operations, many with no relief of their symp-

toms because the visceroptosis was disregarded in the therapy.

CONCLUSIONS

1. When symptoms arise as a result of perverted function in a visceroptotic individual in whom organic disease has been excluded, then, and then only, has visceroptosis clinical significance.

2. The cardinal diagnostic fluoroscopic sign of gastroptosis and coloptosis is that the symptoms are usually relieved when the stomach or colon is elevated manually, and almost immediately entirely relieved when the patient is placed in the Trendelenburg position.

3. The anatomical position of the stomach and colon in the so-called normal individual is dependent upon the habitus as well as the inherited constitutional frame of the individual. Their low position is of no significance except when it interferes with physiological function.

4. The responsibility for the diagnosis of clinical gastroptosis and coloptosis is almost entirely dependent upon the clinical roentgenologist, as a careful objective exclusion diagnosis of organic disease of the gastro-intestinal tract must be made.

DISCUSSION

DR. ROBERT SHOEMAKER (Philadelphia): I have been very much impressed by Dr. Beilin's paper, because it has been my own experience that the clinical men and the surgeons have shown apathy to visceroptosis. I have gone over about 140 cases of this condition at the Lankenau Hospital in Philadelphia and have been much struck by the diversity of the patients' complaints. This series represents cases in which definite organic disease had been excluded so far as possible. A catalogue of the patients' chief complaints looks like an exhaustive list of symptoms occurring in every type of visceral disease—peptic ulcer, cholecystitis, appendicitis, cystitis, renal calculus, and so on. The majority of these patients had consulted several physicians and had received a variety of diagnoses. Obviously, they had not obtained relief. The X-ray findings were perfectly definite and the real problem consisted in demonstrating or excluding true organic disease. Our treatment was directed primarily toward the correction of the ptosis, and for this an external mechanical support was found to be indispensable in the great majority of cases. Systematic checking-up of supports by fluoroscope revealed the fact that the ordinary corset-type or surgical belt was of no use whatever for patients with a flat or a scaphoid abdomen. The iliac crests received the pressure and the ptosed colon, for example, reposed on the bladder and uterus just as it did before. We were obliged to have recourse to a specially constructed apparatus for this type of abdomen, and repeated fittings under fluoroscopic control were often required before the ptosis could be overcome. The rest of the treatment comprised general hygiene, regulation of diet, the exhibition of a few well-chosen drugs, and, last, but not least, a systematic follow-up of patients. The results obtained were often spectacular and nearly always encouraging. A patient that has had a ptosis of long-standing, and has been adequately relieved, is one of the most grateful persons you can meet.

DR. BEILIN (closing): There are a few points I wish to emphasize. The important aspect of my paper is the fluoroscopic diagnostic sign in this condition, which is overlooked to a tremendous extent. That is, these individuals manifest their symptoms on a full stomach when in the upright position. Their symptoms are immediately relieved when the abdominal wall is elevated manually and when the patient is placed in

the Trendelenburg position. The proof of the correctness of the diagnosis is based upon the therapeutic test. Dr. Anders Frick, of Chicago, has made a study of these cases for twenty years, a large number of which have been permanently cured.

The Radioscopical Diagnosis of Filariasis. J. B. Christopherson. Brit. Med. Jour., May 4, 1929, No. 3,565, p. 808.

The X-ray offers a simple and reliable method of diagnosis of filariasis. Filariasis is due to the trematode worm. *Filariasis bancrofti,* which in its adult and larval stages infests the human lymphatics, is a widespread infection in many tropical countries, and is transmitted by three genera of mosquitos—culex, aedes, and anopheles. The only previous means of diagnosis before the onset of elephantiasis was by blood examination for eosinophilia and the presence of larvæ. If, however, the blood examination is negative, as often happens in mild cases where the parent worms are dead, calcified, and encysted, the diagnosis, without the help of the X-ray, is a matter of opinion.

The cyst may be present in any of the skeletal muscles, including the facial muscles. These cysts throw a shadow about half an inch long, thicker at one end, tapering to the other, and the broad end casting a less dense shadow than the tapered end.

WALLACE D. MACKENZIE, M.D.

THE CALIBRATION OF THE "FINGERHUT" IONIZATION CHAMBER[1]

By LAURISTON S. TAYLOR, Associate Physicist, and G. SINGER, Junior Physicist, Bureau of Standards, WASHINGTON, D. C.

A PROBLEM of fundamental importance in the standardization of X-ray dosage is the comparison of the Roentgen units established independently in the several national and local laboratories. It is ordinarily not possible or, perhaps, desirable to have every standardization equipment identical, and consequently any medium for intercalibrating the standards must be capable of being standardized accurately and unambiguously against each standard. Up to the present[2] the only international comparison of X-ray standards has been through the use of the "Fingerhutkammer,"[3] when Behnken carried such a calibrated chamber to several laboratories, measuring the Roentgen unit as determined by each. The discrepancies in the calibrations against the respective standards were then used as correction factors when necessary.

The next problem of practical value is the calibration of the small portable ionization chamber or dosage meter. Since biological reactions are seldom reproducible to within a small percentage, an accuracy of about 4 per cent is usually sufficient for the calibration of a dosage meter which is to be used for medical purposes. If a similar instrument is to be used for comparing standards, the accuracy of calibration should then be 0.5 per cent or better.

In some preliminary investigations it was found, however, that to attain an accuracy of 1.0 per cent in calibrating a small ionization chamber considerable care was necessary, and, moreover, that differences up to several per cent might easily arise, due to differences in the technic used by different investigators. Consequently, a study was made of certain details in the methods for calibrating the thimble ionization chamber and of the probable sources of error involved. For most of the errors it is not deemed necessary to make corrections, inasmuch as special technic permits them to be avoided. We will point out the sources and magnitude in the case of several of the errors, without attempting to provide corrections except in method.

In two earlier papers[4,5] several possible sources of error in the standard ionization chamber were indicated, and it was suggested that they were of such a nature as to admit of the possibility of counterbalancing each other. The magnitude of some of them was determined and the experimental arrangements of several other observers were analyzed for the presence of such errors, which were, in general, found to be small. In the present work it has been found that the errors are not so likely to counterbalance each other, but tend rather in the same direction; that is, they are such that the thimble chamber measures too little ionization.

In this study the standard ionization chamber of the Bureau of Standards was used as a reference for all measurements. A number of different types of dosage meter were available,[6] of which two were chosen as being representative of all those employing the more commonly used thimble cham-

[1]This is Research Paper No. 169. Reprinted by permission from the *Bureau of Standards Journal of Research*, May, 1930, IV.

[2]Behnken, Hermann: Strahlentherapie, 1928, XXIX, 192.

[3]The more common designation of the small chambers used in connection with dosage meters is the original German term, "Fingerhutkammer." In the future we shall use the term "thimble chamber" for this device.

[4]Taylor, L. S.: Bureau of Standards Jour. Research (Research Paper No. 56), 1929, II, 771.

[5]Taylor, L. S.: Bureau of Standards Jour. Research (Research Paper No. 119), 1929, III, 803.

[6]Other dosage meters available were of the following types: Furstenau, Müller, Küstner "Eichstandgerat," Solomon, and Wulf. Of these, the Furstenau and Küstner instruments do not involve the use of a "Fingerhutkammer."

ber. Consequently, our study was confined to the Friedrich and the Glasser chambers, each, however, being used in conjunction with the same string electrometer.

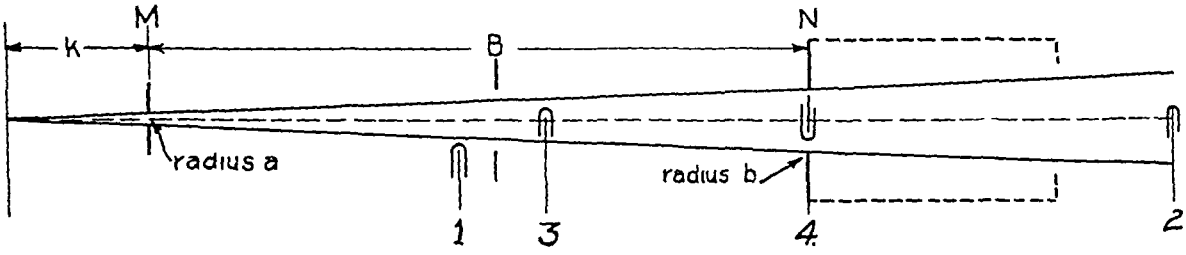


Fig. 1. Arrangement of diaphragms and thimble chambers for calibration.

II. ENERGY DISTRIBUTION ACROSS SECTIONS OF THE STANDARD X-RAY BEAM

The most important requirement for the standard X-ray beam is that it be uniform over the entrant diaphragm of the standard ionization chamber.[7 8 9 10] Beam uniformity over the area of the thimble chamber is likewise the outstanding requirement in the comparison against the standard. Below are given a number of curves showing the energy distribution over a section of the X-ray beam, illustrating correct and incorrect conditions.

The presence of the limiting diaphragm near the tube complicates matters somewhat. It has been found, however, that for standard ionization chamber measurements such a diaphragm near the tube has certain advantages in avoiding the effect of off focus[11] and stem radiation, although its use necessarily makes the uniform area of the beam small. As a consequence, if we have a thimble chamber whose length is from 1.5 to 4 cm., it is clearly possible that, while the X-ray beam may be sufficiently uniform over an area necessary for the standard, it does not necessarily satisfy the requirements of the small chamber except at comparatively great distances from the tube. On the other hand, if the beam uniformity is made to satisfy the small chamber by, say, enlarging the limiting diaphragm next to the tube, then an error may be introduced in the standard determination due to off-focus radiation. It is evident then that the two measurements must be carefully made with proper regard to these conditions if an accurate calibration is to result.

In calibrating a small chamber the various methods used may be reduced to four, as indicated diagrammatically in Figure 1. The first[12] (Position 1) places the thimble chamber between the X-ray tube and standard ionization chamber *N*, and sufficiently off the axis of the X-ray beam so that it does not intercept the part of the beam entering the standard chamber. The ionization currents are then measured simultaneously and the inverse square law applied to the two. This is the system used by Behnken and, as seen, assumes that the beam is uniform over a comparatively wide area. In the second method (Position 2) the thimble chamber is beyond the standard and on the same axis; the readings are made simultaneously and the inverse square law applied. The third (Position 3) involves a substitution method, the thimble chamber being inserted between the tube and the standard on the axis of

7Taylor, L. S.: See Footnote 5.

8Mayenord, W. V.: Brit. Jour. Radiol., I, 125.

9Glasser, Otto, and Portmann, U. V.: Am. Jour. Roentgenol. and Rad. Ther., 1928, XIX, 47.

10Behnken, Hermann: Strahlentherapie, 1927, XXVI, 79.

11Off-focus radiation is defined as that radiation from an X-ray tube which originates from points on the target face other than the sharply defined focus.

12Behnken, Hermann: See Footnote 10.

the beam which is utilized by the standard; the readings are taken separately and the inverse square law applied. The fourth (Position 4) also involves a substitution since an extremely steady X-ray equipment, controlled by a specially constructed voltage stabilizer, is available. In this equipment the standard and small chambers are fixed

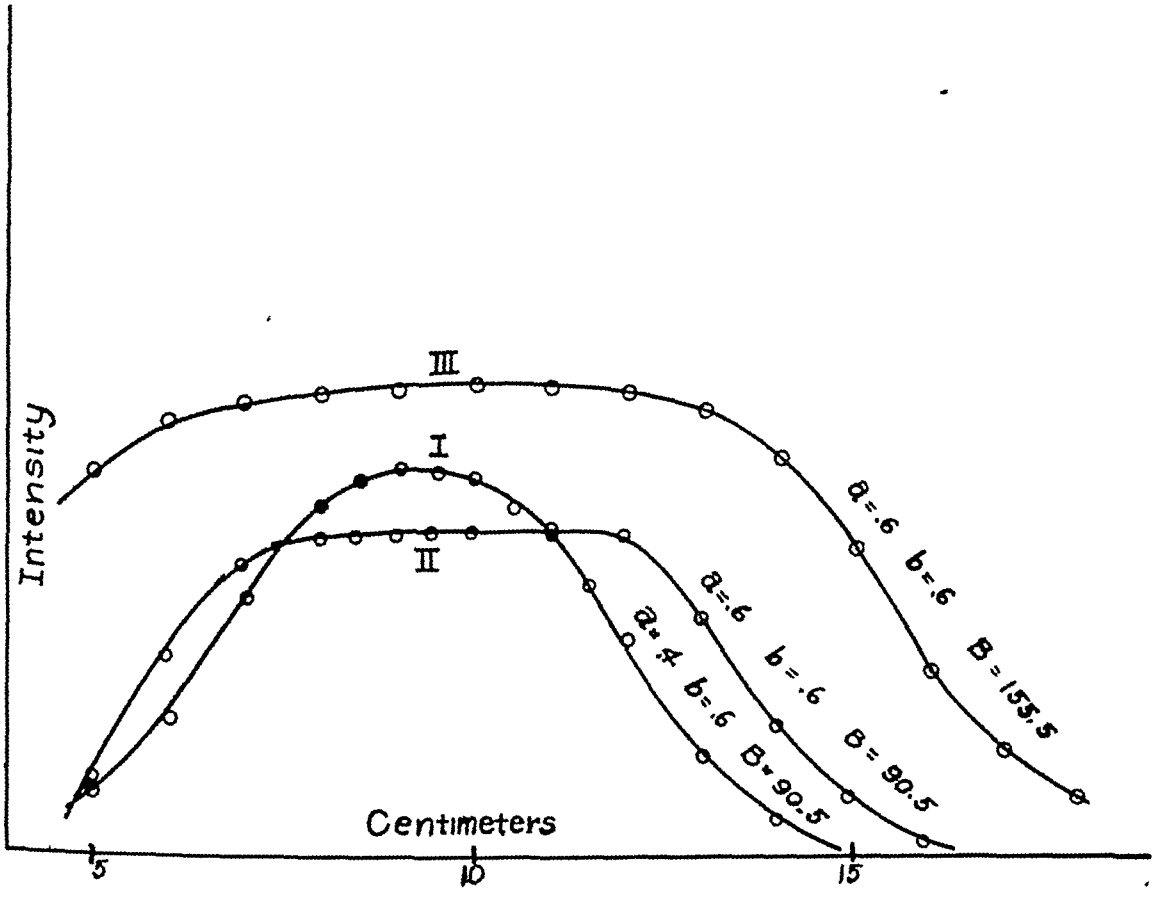


Fig. 2. Intensity distribution across standard X-ray beam (measured with standard chamber).

method,[13] the thimble chamber being inserted in the position occupied by the front diaphragm of the standard and the use of the inverse square law thus avoided—a very desirable feature. The first two methods have the advantage of simultaneous measurement, thus minimizing the effects of an unsteady source of radiation. The choice of any of the methods will depend upon the beam uniformity, which in turn depends on the limiting diaphragm M and the applicability of the inverse square law. The last method is used by the Bureau of Standards, in position, while the X-ray tube and beam are shifted laterally from one to the other, keeping the relative position of target to chamber the same for both.

The uniform distribution of energy across the beam may be tested most easily by means of an ionization chamber. Photographic determinations are more accurate if carefully executed, inasmuch as there is no effective slit width for which allowance must be made. Figure 2 shows for several diaphragm combinations and distances from the X-ray tube, the intensity of ionization measured by the standard chamber as the

[13] Glasser, Otto, and Portmann, U. V.: See Footnote 9.

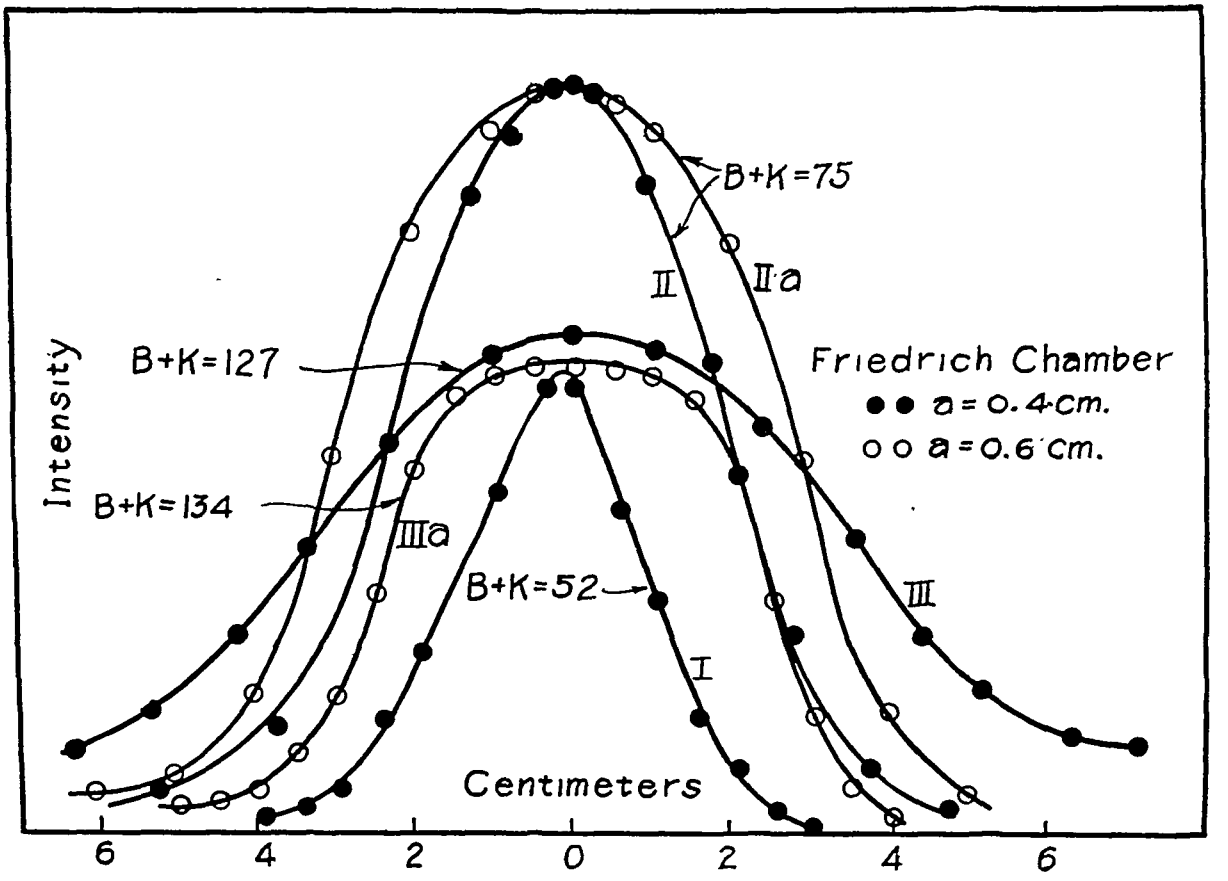


Fig. 3. Intensity distribution across standard X-ray beam (measured with thimble chamber).

beam is moved laterally across the entrant diaphragm *N*. (The curves are plotted on different scales so that the relative ordinates are without significance.) For all of this study the focal spot had a radius of about 0.6 cm. and the diaphragm *M* likewise a radius of 0.6 cm. except where otherwise indicated. In Curves I and II the distance from tube to chamber was 90.5 cm., while the radii of the limiting diaphragm *M* were 0.4 and 0.6 cm., respectively. In Curves II and III, both diaphragms had 0.6 cm. radii and the distances were 90.5 and 155.5 cm., respectively. It will be noticed that under the conditions of Curve I the peak of the curve is relatively narrow; hence, proper alignment of the system is very necessary, so that, if possible, such conditions are avoided. By increasing the size of diaphragm *M* to a radius of 0.6 cm. (Curve II) the peak is considerably broadened. though it is not of uniform intensity over its width. However, the increase in *M* may be undesirable in that it allows "off-focus" radiation to enter the standard chamber. Curve III is similar to II except that it has a broader peak. It is also of interest to note that all curves are very nearly symmetrical. This indicates a correct adjustment of the limiting diaphragm *M*, since if *M* were out of alignment, off-focus radiation would show up as a dissymmetry. After correcting for the diameter of the large diaphragm. the measured width of the peaks agree fairly well with the calculated widths.

The calibration of a thimble ionization chamber placed in the X-ray beam under conditions corresponding to Curve I, would be in doubt if not in serious error, since the X-ray intensity would not be uniform over the length of the chamber. Placed in the beam corresponding to Curve II, the flux

density of the beam would be sufficiently uniform, but, due to the very large diaphragm M used in the standard system, an error due to off-focus radiation is introduced in the standard which rules out such an arrangement. A calibration of the fourth type, however, would be satisfactory under conditions corresponding to III, in that the beam is uniform over the length of the thimble chamber and at the same time off-focus radiation is excluded from the standard chamber.

If now, using a thimble ionization chamber (Friedrich in this case), we measure the energy distribution across the beam, the symmetry usually disappears and the width of the peak is apparently diminished. In general, any dissymmetry is due to the construction of the thimble chamber, which is such that the measured ionization is not uniform over its length. The apparent narrowness of the peak is caused by the large "effective slit width" of the Friedrich chamber, the actual uniform part of the beam being some 2 cm. greater in diameter.

Figure 3 gives a set of such energy distribution curves under several different sets of conditions, Curves I, II, and III being taken with a limiting diaphragm M of diameter 8 mm., and curves IIa and IIIa with a limiting diaphragm M of diameter 12 millimeters. With the standard chamber at the same relative positions as indicated for the thimble chamber and the diaphragm M having an 8 mm. diameter (first case), the off-focus radiation is definitely excluded, and an accurate standardization of the beam may be effected. With the diaphragm M having a 12 mm. diameter (second case), off-focus radiation enters the chamber and impairs the results.

III. THE INVERSE SQUARE LAW FOR THIMBLE CHAMBERS

In a paper referred to above[14] it was shown that, depending on whether the target, as viewed from the position of the chamber diaphragm, does or does not fill the aperture of the target diaphragm, the inverse square for computing intensity is applied, respectively, to the target diaphragm distance, or the target distance. Thus, when the ionization chamber diaphragm fills the aperture of the system,[15] the distance must be measured between the limiting diaphragm M and the chamber diaphragm N. This condition becomes more important when using large ionization chamber diaphragms.

Since to obtain sufficiently large effects, most thimble ionization chambers subtend a fairly large solid angle as measured from the focus, the inverse square law was investigated in a manner similar to that used for the standard chamber. The thimble chamber and electroscope tube were mounted so as to move along a track 2 m. long, placed parallel to the X-ray beam. The vertical and horizontal alignment was determined by measurement as above, the chamber being placed in the center of the uniform area of the beam. Ionization currents in the thimble chamber were measured for various settings of the chamber along the track, the position being measured with reference to the diaphragm M.

Plotting the intensity (I) against the square of the reciprocal distance ($1/B^2$), it is seen in Figure 4 that there is a distinct break in the curves. Three such curves are given: Curve G for a Glasser 1 cm.^{3} chamber, and Curve F for a Friedrich chamber, the first having an outside length of 2.9 cm. and the second an outside length of 2.7 centimeters. It will be seen also that the break in Curve G occurs at a position corresponding to a distance farther from the tube than the break in Curve F. Likewise the curves for both Friedrich and Glasser chambers break at a point farther from the

[14] Taylor, L. S.: See Footnote 5.

[15] The aperture of the system is defined as the solid angle subtended by the focal spot and the limiting diaphragm M (Fig. 1).

tube than a similar Curve S for the standard chamber. It is seen that the lower portion of each curve passes through the origin, indicating that the inverse square law is obeyed only beyond a certain distance from the X-ray tube. Also on the Curve G it is seen that the points 1, 2, and 3 are far off the straight portion covering smaller distances. This divergence is caused by approaching too closely to the tube where the beam intensity varies very rapidly across the diameter occupied by the chamber. (See Curve I, Fig. 3.)

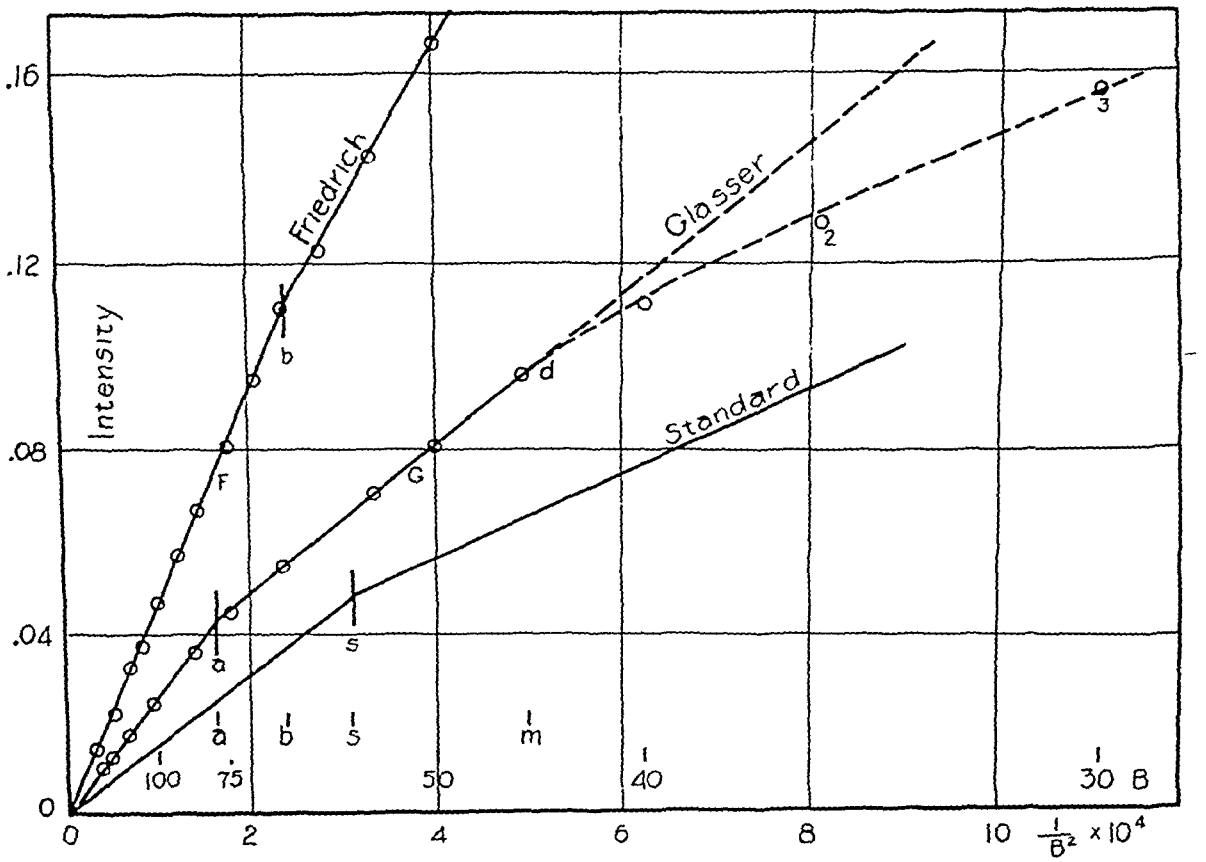


Fig. 4. Divergence from the inverse square law for three ionization chambers.

If we replot these same data as log I against log B, we may determine the exact divergence from the inverse square law. (Fig. 5.) If the inverse square law is obeyed, the points should lie along a straight line having a slope of −2.0. Actually it is seen that for a Friedrich chamber only the portion bF has a slope of approximately −2.00, for a Glasser chamber the portion aG, these points corresponding to distances far from the tube. If we plot log I against log $(B+k)$ for the Friedrich chamber, it is seen that the part $b'W$ most nearly approaches the slope −2 (being actually −2.04), corresponding to distances near to the tube. It is important to notice that the inverse square law is not obeyed exactly over any of the range of $(B+k)$. This bears out the conclusion drawn in an earlier paper[16] that the use of an extended source of radiation appears to be preferable for precise X-ray standardization.

By analogy to the case of the standard chamber, where now the thimble chamber

[16] Taylor, L. S.: See Footnote 5.

replaces the standard chamber diaphragm, we should expect a divergence from the inverse square law at the position where the focal spot, limiting diaphragm and standard chamber diaphragm (half the effective length of the small chamber in this study),

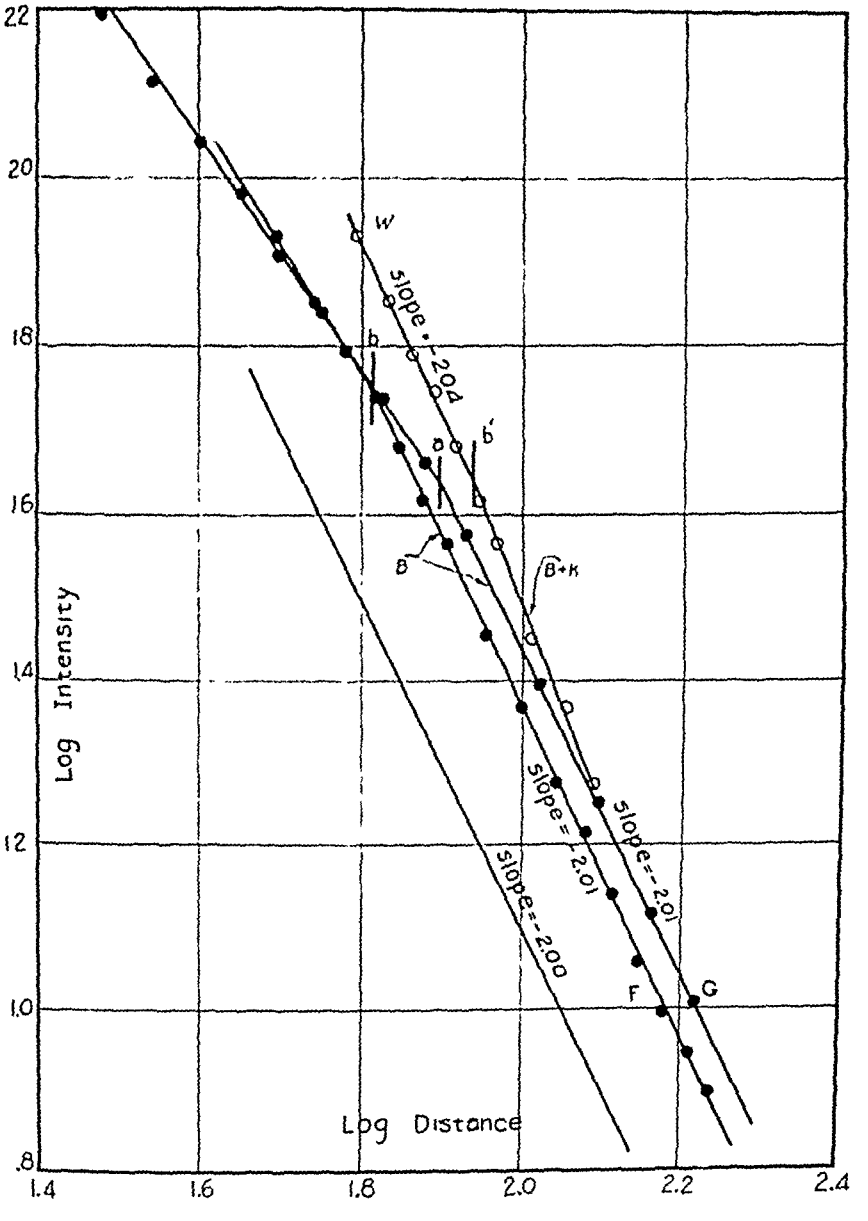


Fig. 5. Inverse power law for three ionization chambers.

thimble chamber no longer fills the aperture of the system.[17] This should be at such a distance that

$$f = \frac{ka + kb + aB}{B}$$

where f, a, and b are the respective radii of and B and k are as indicated in Figure 1. However, it is impossible to determine the effective length of the chamber accurately, hence, merely the order of magnitude of B can be calculated.

Having observed such a discontinuity in the intensity curve for the thimble chamber, we are confronted with the question of com-

[17] See Equation (7) and Fig. 1 (c) in Taylor, L. S.: Bureau of Standards Jour. Research (Research Paper No. 119), 1929, III, 803.

paring the ionization measurements of standard and thimble chambers. Curve "Standard" in Figure 4 is for the standard chamber when using the same limiting diaphragm M and an arbitrary standard chamber diaphragm N. It is seen that the break point for this curve differs from the first two.

Referring to Figure 5, we find that when the thimble chamber is used at such distances that the inverse square law is applied to the diaphragm M, the exponent of the distance is –2.01, thus differing from –2.00 by 0.5 per cent. On the other hand, for such distances that the inverse square law is applied to the target, the exponent is about –2.04, giving a difference of 2.0 per cent from –2.00. Correspondingly, we find when using a standard in place of a thimble chamber that the divergence of the respective exponents agrees in order of magnitude with the thimble chamber. Thus, if one chamber is calibrated against the other over regions where their exponents agree, the errors introduced will neutralize each other. However, if the calibration is made over regions where the two exponents differ, there will be an error of about 1.5 to 2.0 per cent. In other words, for calibration purposes, conditions should be so selected that either both chambers fill the aperture of the system or neither chamber fills it. Thus for the Glasser chamber the comparison should be made in the regions O to a or s to m and not in the region a to s. When calibrating dosage meters for medical uses the errors introduced as above may not be serious, whereas for standardizing purposes their magnitudes warrant proper consideration.

IV. DISTRIBUTION OF IONIZATION IN THIMBLE CHAMBERS

In studying the general behavior of a thimble chamber it is important to know the distribution of ionization in the chamber itself. (See Sec. II.) For instance, it was found when measuring the intensity distribution across the beam that the peak of the intensity curve did not always coincide with the position of the geometrical center of the particular chamber used to determine it. To check this the beam center was obtained accurately by means of a Glasser 1/20 cm.^{3} chamber and the geometrical center of the larger (1 cm.^{3}) chamber set at this point, after which it was usually found that the 1 cm.^{3} chamber had to be shifted slightly in order to obtain the maximum ionization reading. This means that we cannot rely upon the geometrical center as the true center point in aligning the chamber for calibration.

To measure the distribution of ionization in the thimble chamber (and likewise to obtain the effective center), the X-ray beam was defined by a long slit about 1 mm. wide and the chamber moved across this beam by small steps in a direction parallel to the chamber axis and at right-angles to the long axis of the slit, so that at any position only a small portion of the chamber air volume was ionized by the direct beam. Figures 6 and 7 show the distribution of ionization in a 1 cm.^{3} Glasser and a Friedrich chamber, respectively. Below each curve is a half-section scale drawing of the corresponding chamber. In the case of the Friedrich chamber the center of the ionization peak agrees fairly well with the geometrical center. However, due to the very uneven ionization at the ends it is difficult to predict the true effective center when used in a broad beam. There is a marked increase in the ionization at the end of B of the chamber, this being due to the metal collar which supports the chamber cap. The case of the 1 cm.^{3} Glasser chamber is similar, although the center of the ionization peak is farther from the geometrical center, while the scattering at the end B appears to be negligible.

As pointed out in Section II, it is not ordinarily possible to calculate the break point

in the inverse square law from the measured length of the thimble chamber; however, having found the break point we may attempt to calculate the effective length of the chamber by reversing the process. A comparison of the values given in Column

TABLE I

Chamber	Measured length (cm.)	Calculated length (cm.)	Experimental length (cm.)
Friedrich.....	2.7	2.5	2.0
Glasser.....	2.9	2.1	2.0

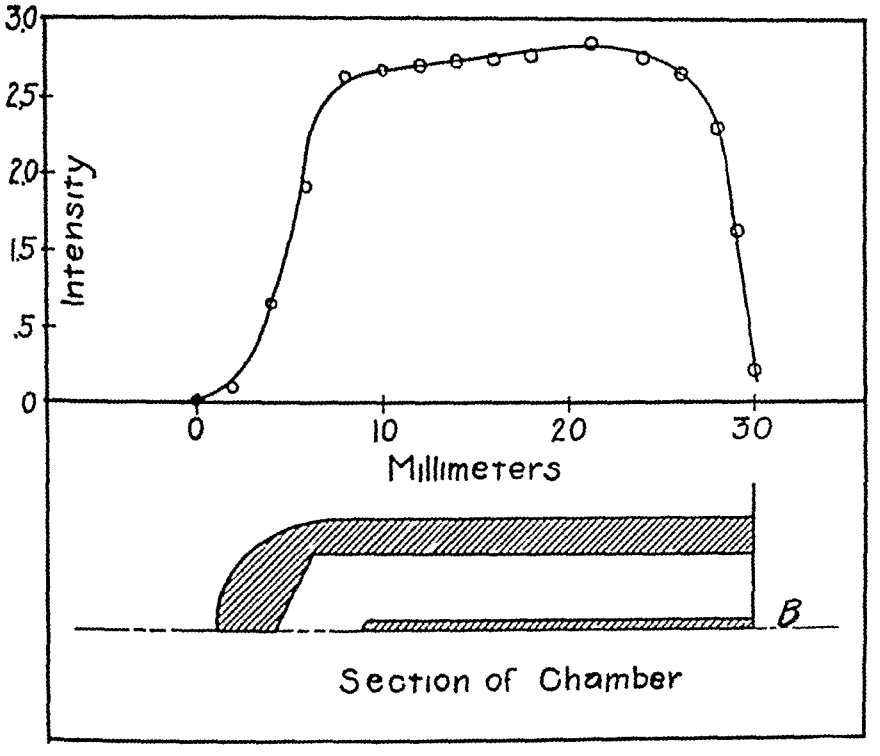


Fig. 6. Distribution of ionization along axis of Glasser chamber.

3 of Table I, obtained in this way, with the over-all geometrical length given in Column 2 shows at once the futility of trying to calculate the working range for standardization on the basis of the measured chamber length. The fact that the experimental length given in Column 4, obtained by measuring the width of the peaks in Figures 6 and 7, is the same for both the Friedrich and Glasser chambers would lead to the conclusion that the working range of the inverse square law was the same for both, and yet Figure 4 shows that their break points differ by 8 centimeters.

V. SATURATION CONDITIONS IN THIMBLE CHAMBERS

When a small ionization chamber is used with a medical-dosage meter the system is always charged to a potential of the order of 300 to 500 volts, thus assuring complete saturation of the chamber. In such cases the working sensitivity is comparatively low, requiring very long exposures for the radiation ordinarily used in treatment—an undesirable feature when using the small chamber for an intercomparison between two standards, since the likelihood of severe

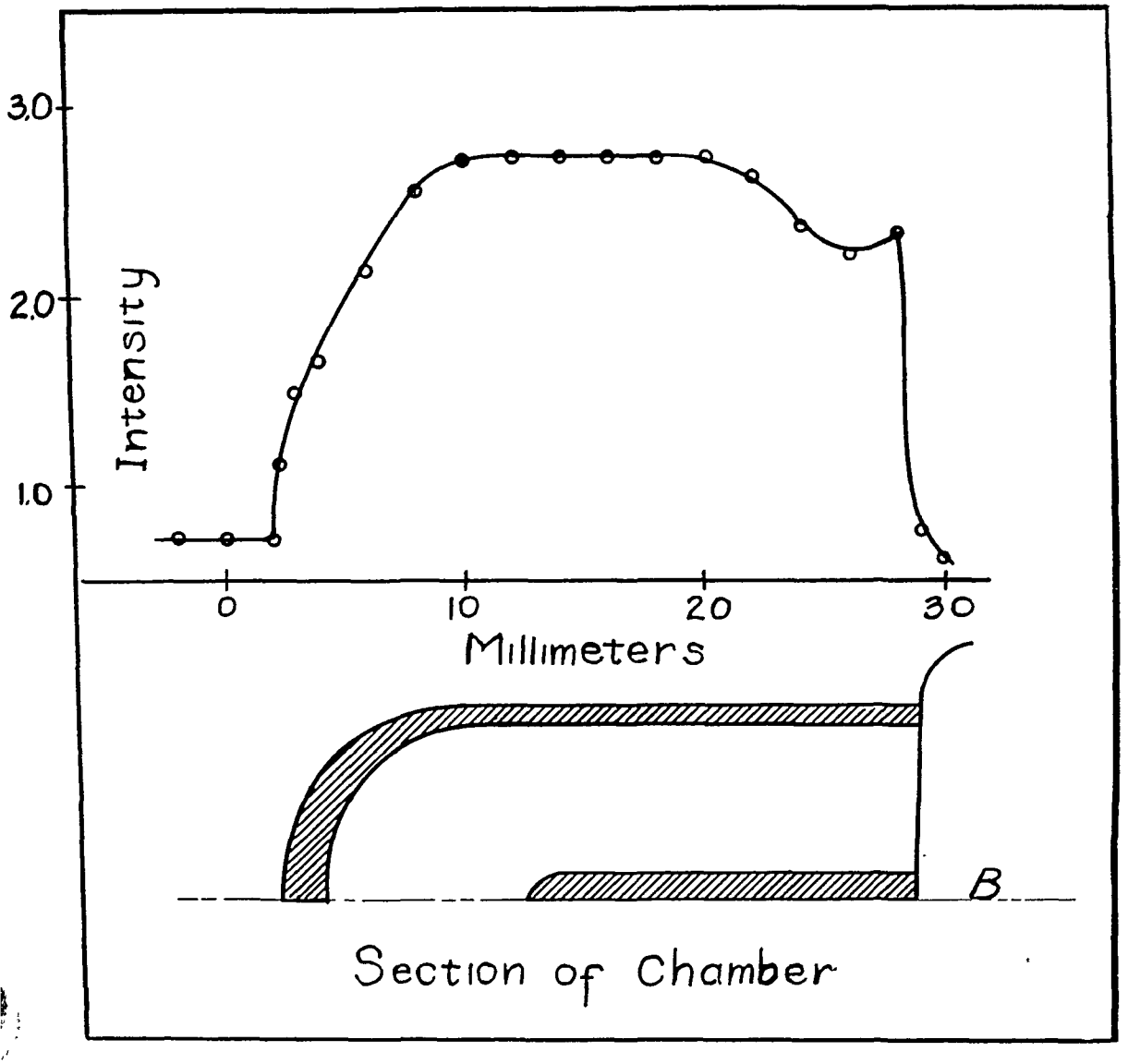


Fig. 7. Distribution of ionization along axis of Friedrich chamber.

fluctuations in beam intensity is greater for long-time intervals. As a consequence lower charging voltages (50 to 100) are frequently used, thus increasing the working sensitivity of the system.[18] It is questionable whether there is always complete saturation under such conditions.[19 20]

To test this a system was arranged so that a full-scale deflection of the electrometer corresponded to a potential of about 50 to 100 volts on the ionization chamber electrode. With the chamber exposed to a steady source of radiation, times of transit were measured for, say, every five divisions on the electrometer scale. Plotting time against the voltage corresponding to each scale reading a straight line would indicate uniformity of measured ionization; that is, saturation. It was found, however, that actually there was a slight curvature below

[18]The ionization current is proportional to the loss of potential of the system per unit time. The tension of the electrometer fiber is adjusted to give a full-scale deflection for any voltage used on the chamber, so that when exposed to the same radiation, for equal scale deflections the time is less, the lower the full-scale voltage on the system.

[19]Fricke, Hugo, and Glasser, Otto: Am. Jour. Roentgenol. and Rad. Ther., 1925, XIII, 453.

[20]Braun, R., and Küstner, H.: Strahlentherapie, 1929, XXXII, 550, 739.

about 50 volts for the particular chamber. The average ionization current over any interval is proportional to $\Delta V/\Delta t$, the voltage increment over the time interval. Thus, plotting $\Delta V/\Delta t$ against V we may obtain a saturation curve for the chamber in question. Such a curve for a Glasser chamber is shown in Figure 8. There is considerable error in obtaining such a curve, but the trend of the points indicates beyond any question that there is not complete saturation below 50 volts.

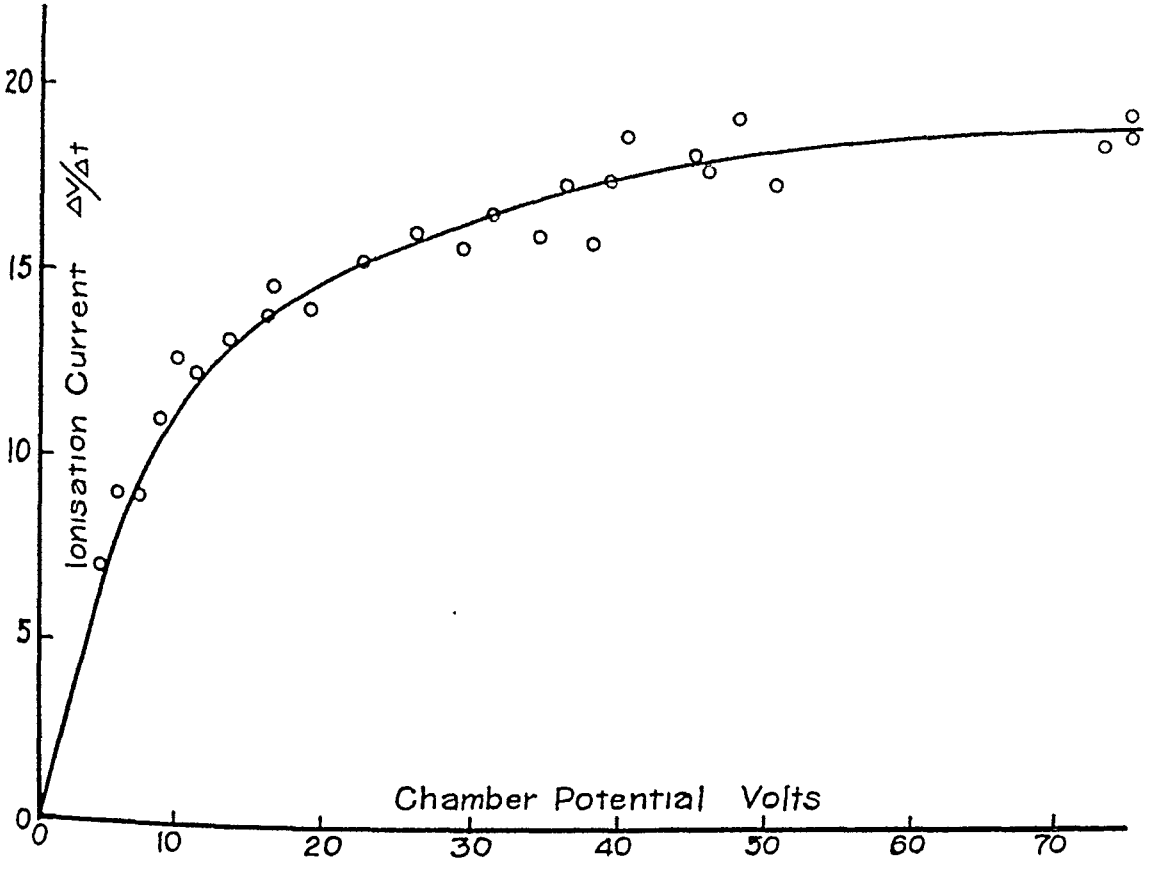


Fig. 8. Voltage saturation curve for thimble chamber.

VI. "WALL EFFECT" IN THIMBLE CHAMBERS

It has been well recognized that, for most small ionization chambers, the "wall effect" has a very decided influence upon the ionization measured.[21] [22] It was this effect which prompted Fricke and Glasser[23] to develop the "air wall" chamber in which the walls are made up of a compound having the same effective atomic number as air, and in which the ionization is closely parallel to that in an unrestricted volume of air. However, the extensive use of chambers having walls of graphite, magnesium, horn, celluloid, etc., which do not fulfill this condition, makes it necessary to establish some correction factor for the wall effects. Behnken[24] applies a correction determined by the half value layer in copper for each kind of radiation used. His method is probably sufficiently accurate and there seems little chance of improvement unless a standard source of X-rays in which there is a fixed energy distri-

[21] Glasser, Otto, and Portmann, U. V.: See Footnote 9.
[22] Behnken, Hermann: See Footnote 10.
[23] Fricke, Hugo, and Glasser, Otto: Am. Jour. Roentgenol. and Rad. Ther., 1925, XIII, 462.
[24] Behnken, Hermann: See Footnote 2.

bution is established. This might be approached by using constant potential on a tube of somewhat special but nevertheless simple construction. However, to introduce the X-ray tube being shifted from one system to the other between readings.

Observations may be made in two ways, depending upon the kind of X-ray equip-

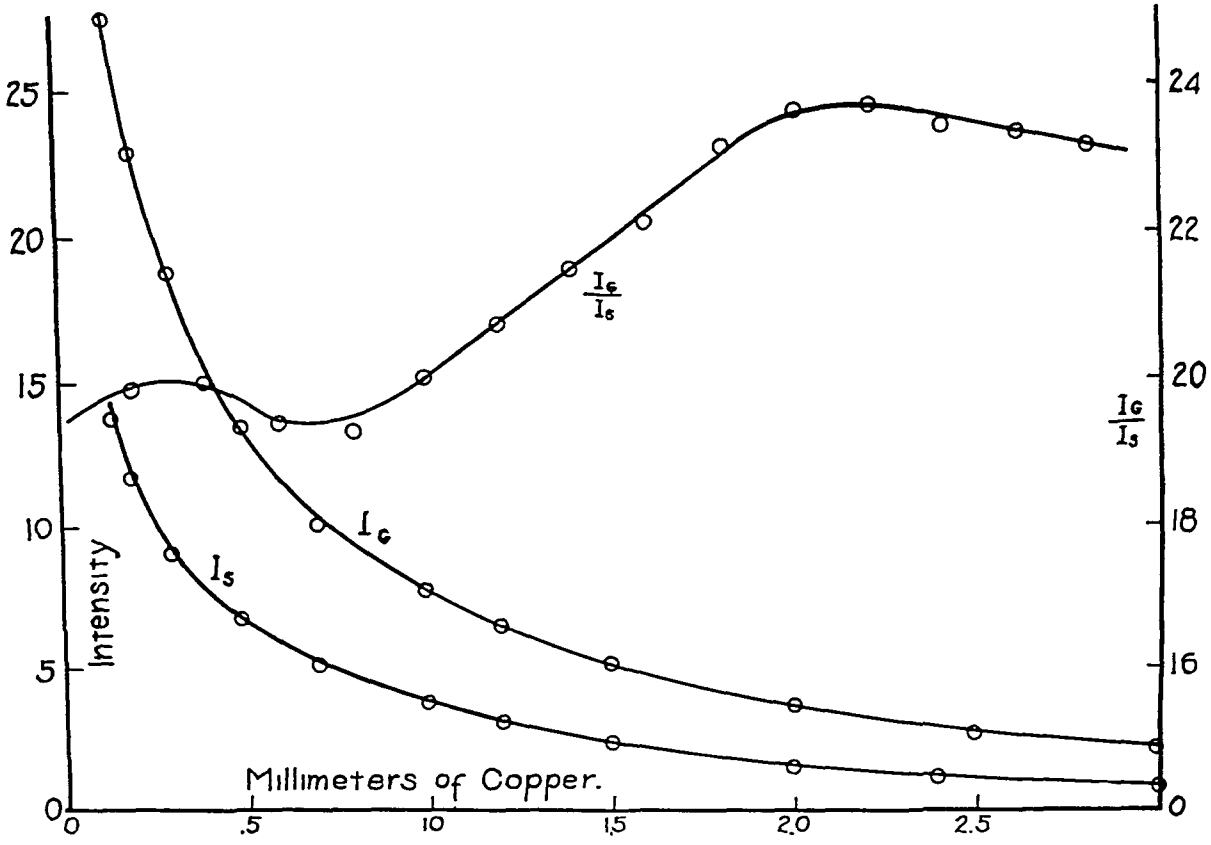


Fig. 9. Dependence of measured ionization in a thimble chamber as a function of filtration.

the further complication of a standard source of X-rays does not seem warranted at this time.

To show the deviation introduced by the wall effect comparisons were made against the standard chamber, as indicated in Figures 9 and 10. The Glasser chamber is made of graphite, while the Friedrich chamber is horn coated with graphite, these being representative of all of the small chambers available. They were each used with the same electroscope—a modification of the Lutz-Edelman, constructed at the Bureau of Standards. Readings were taken alternately with those of the standard chamber, ment and the control available. The first method is to maintain a given filter in the beam and vary the voltage, and the second is to maintain the voltage constant and change the filter. In both cases the ionization readings of the two chambers are compared.

Figure 9 shows two copper absorption curves made with the standard and the Glasser chambers, respectively, at a tube potential of about 160 K.V. On the same chart is shown the ratio I_g/I_s, obtained from the curves I_g and I_s. It is seen that this ratio varies from about 19.5 to 23.7, or about 9.5 per cent from the mean. If we could know

that at any point the ratio was correct, then a simple correction for the remaining points could be made. Practically, however, this is impossible. Again, for the same chamber the ting and reading the curves. The importance of the curves lies in showing the complete lack of parallelism in the ionization as measured by the two methods.

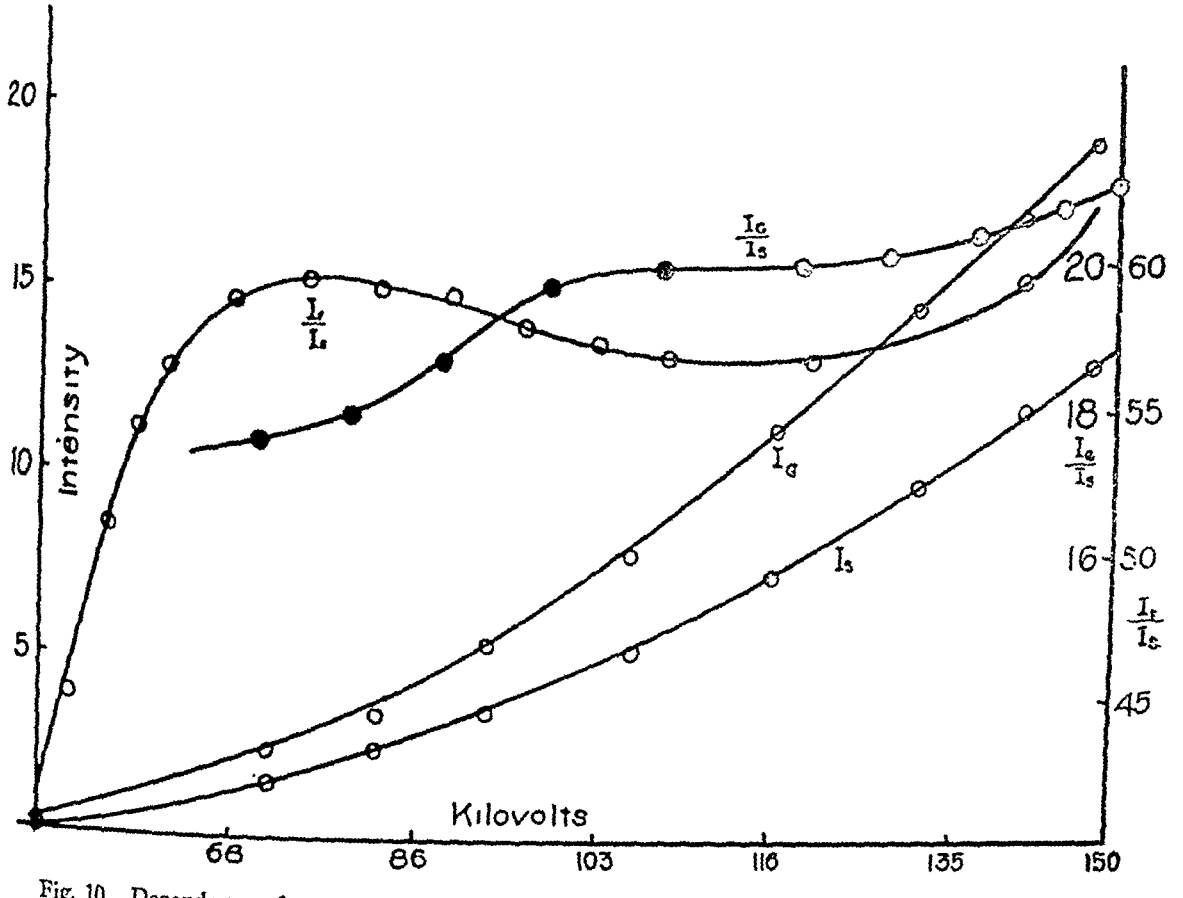


Fig. 10. Dependence of measured ionization in a thimble chamber as a function of voltage applied to X-ray tube.

filter was fixed at 0.6 mm. copper and the voltage varied over a wide range. Figure 10 gives the corresponding I_g and I_s curves and again the ratio I_g/I_s. In this case the ratio varies from 17 to 21, or about 10 per cent from a mean value. As would be expected in both cases, the greatest variation occurs at low voltages and small filtration, under which conditions there is a large amount of soft radiation in the beam. It should be pointed out that in the I_g/I_s curves there may be an error of 2 or 3 per cent, since the ratio is obtained from two sets of experimental data each having a small error, and since there may also be some error in plotting and reading the curves. The importance of the curves lies in showing the complete lack of parallelism in the ionization as measured by the two methods.

In order to obtain some idea of the relation between the measured ionization in two different thimble chambers, Figure 10 also shows a curve of $I_f I_s$ for a Freidrich chamber under conditions identical with those for the Glasser chamber. It will be pointed out only that the form of the $I_f I_s$ curve is quite different, as might be expected from the differences in construction between the two chambers.

The most important result of the investigation has been to show the inadequacy of the thimble ionization chamber as a medium through which to compare the fundamental standards in various laboratories. An al-

ternative method has been under investigation for several months and will be described in detail at an early date.

VII. SUMMARY

As indicated in the body of the paper there are five factors which must be taken into consideration when calibrating a "Fingerhut," or thimble ionization chamber, against an accepted form of standard air ionization chamber. A summary of the possible errors follows:

1. That due to variable energy distribution across the standard X-ray beam. In general, a standard beam will have but a narrow region in its center where the intensity is nearly uniform. Improper placement of the thimble chamber in this beam tends to make the thimble chamber indicate too low X-ray intensity.

2. When the uniform area of the X-ray beam is too small to entirely cover the thimble chamber, too low X-ray intensity will, in general, be indicated by the ionization measured in the chamber.

3. Less than saturation voltage on the thimble chamber will also indicate too low intensity. (Saturation is usually assured in medical dosage meters, but not always in the case of standardization dosage meters.)

4. Improper application of the inverse square law applied in standardizing the thimble chamber will, in general, produce an error in the direction of measuring too low X-ray intensity.

5. The "wall effect" in any but the "Fricke-Glasser air wall chamber" may produce an error in either direction, depending upon the particular chamber used. In general, this effect is so pronounced that an accurate calibration is obtainable only under identical conditions regarding filtration, tube potential, and wave form of the generating equipment.

Some of these factors are of little importance when calibrating a dosage meter which is to be used only for medical purposes. However, if such a dosage meter is to be used for standardizing purposes or for comparing different standards, each factor must be carefully considered.

THE CRYSTAL STRUCTURES OF TRIMETHYL AND DIMETHYL ETHYL SULPHONIUM CHLOROSTANNATES AND OF METHYL TRIETHYL PHOSPHONIUM CHLOROSTANNATE

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Rockefeller Institute for Medical Research, NEW YORK CITY

DATA upon the structures of several substituted ammonium chlorostannates[1] have already been published. The present determinations continue these studies by replacing the substituted ammonium radicals with corresponding sulphonium and phosphonium groups.

All three of the crystals described in this paper appear to be optically isotropic and cubic in form. Although no previous crystallographic description of them could be found, the corresponding chloroplatinates[2] are reported to form optically isotropic octahedra or octahedra with small hexahedral faces. Only octahedral faces were found on any of the crystals, but Laue photographs of the trimethyl and dimethyl ethyl sulphonium chlorostannates taken normal to (111) show plainly the hemihedry characteristic of Ti (T^h) or T. Although these sulphonium salts crystallized readily, producing clear, well-formed octahedra of fair size, single crystals of methyl triethyl phosphonium chlorostannate large enough for Laue or oscillation photographs were not obtained.

The preparation of each chlorostannate was effected by neutralizing the appropriate substituted phosphonium or sulphonium hydroxide with HCl and adding an aqueous solution of H_2SnCl_6. These hydroxides were made by R. E. Marker of this Institute.

The crystal structures were determined in the usual fashion from Laue, oscillation spectral and powder photographs.

[1] Wyckoff, R. W. G., Am. Jour. Sci., 1928, XVI, 349.
Idem, Ztschr. Kristallographie, 1928, LXVIII, 231.
Wyckoff, R. W. G., and Corey, R. B., Am. Jour. Sci., 1929, XVII, 239.
Idem, Am. Jour. Sci., 1929, XVIII, 138, 437.

[2] See Groth, Paul, Chemische Krystallographie, Leipzig, 1906, I, 479, 482.

THE CRYSTAL STRUCTURE OF TRIMETHYL SULPHONIUM CHLOROSTANNATE

The data for this study were obtained from Laue photographs and from oscillation photographs using both copper and molybdenum radiation.

Six comparison photographs were made between the (111) face of $[(CH_3)_3S]_2SnCl_6$ and the (001) face[3] of β—Al_2O_3 (d_{001}= 11.24 Å.) using copper radiation. The average of eighteen reflections taken from the first, second, and third orders on these photographs gives d_{111} = 7.17 Å., which leads to the length of a cube edge a_o=12.41 Å. The density as obtained by the ordinary suspension method is $\rho_{20°}$ = 1.69. Calculation from this density shows that a unit cube having the foregoing a_o will contain four molecules (m = 4.03). Data from an oscillation spectral photograph using molybdenum radiation are reproduced in Table I. Typical results on an octahedral Laue photograph are listed in Table II. Although the strongest first order reflections have only odd indices, such reflections occur from all sorts of planes so that the fundamental lattice is Γ_c. Of the possible first order spots with one index zero those are found which are (0, even, odd), whereas those that are (0, odd, even) and (0, odd, odd) are invariably absent. This is the distinguishing criterion of Ti-6 (T_h^6), which, therefore, is

[3] Pauling, Linus, and Björkeson, Albert, Proc. Nat. Acad. Sci., 1925, XI, 445.

TABLE I

TYPICAL REFLECTION SPECTRAL DATA UPON PHOTOGRAPHS OF TRIMETHYL SULPHONIUM CHLOROSTANNATE

[(111) as Principal Spectrum]

Indices	Intensity	Indices	Intensity
111	v.s	220	s
222	f	440	m
333	ff	002	m
444	f	004	v.s
555	ff	113	m
553	ff	224	f+
551	f—	115	s
		226	f

TABLE II

TYPICAL LAUE DATA FROM AN OCTAHEDRAL PHOTOGRAPH OF TRIMETHYL SULPHONIUM CHLOROSTANNATE

Indices	Spacing	Wave Length	Intensity
$0\bar{4}5$	2.24 Å.	0.483 Å.	f—
$1\bar{4}4$	2.17	.482	f—
$\bar{3}5\bar{1}$	2.11	.446	v.s
$\bar{5}42$	1.86	.491	f
$34\bar{5}$	1.76	.487	ff
$\bar{3}15$	1.75	.392	m
$25\bar{5}$	1.70	.458	f—
$\bar{3}72$	1.58	.475	f

in all probability the correct space group. The atomic arrangement then is as follows:[4]

Tin atoms: 4b.

Sulphur atoms: uuu and other seven positions of 8h.

Chlorine atoms: xyz and other general positions of Ti-6.

Carbon atoms: x'y'z' and another set of general positions of Ti-6.

The structure of $[(CH_3)_2S]_2SnCl_6$ is, therefore, similar to that[5] of $[(CH_3)_2NH]_2SnCl_6$. Lack of the necessary F-curve data makes unprofitable an attempt to establish exact atomic positions at this time.

THE CRYSTAL STRUCTURE OF DIMETHYL ETHYL SULPHONIUM CHLOROSTANNATE

Data were obtained from Laue photographs and from oscillation photographs using molybdenum radiation. Six comparison spectra were made between the (111) face of $[(CH_3)_2(C_2H_5)S]_2SnCl_6$ and the (100) face of calcite. An average of sixteen reflections taken from the second, third, and fourth orders gives $d_{111} = 7.39$. From this the length of the unit cube edge is $a_0 = 12.80_5$. The density $\rho_{20^\circ} = 1.63$ leads to a unit cube which contains four molecules ($m = 4.04$). Typical data from an octahedral Laue photograph are contained in Table III. Reflections from an oscillation spectrum are listed in Table IV. All agree with a four molecule unit. There is a striking similarity between both the Laue and spectral data and those obtained from $[(CH_3)_2S]_2SnCl_6$. Possible first order reflections with one index zero include only those which are (0, even, odd), so that the space group would appear to be Ti-6.

In several of the other substituted chlorostannates which have been investigated, difficulties have been encountered in placing the hydrocarbon groups in positions which were chemically reasonable and which at the same time conformed to the apparent symmetry. In $[(CH_3)_2(C_2H_5)S]_2SnCl_6$ this seems impossible. No cubic group which could explain the observed diffraction effects has the requisite atomic positions. Ordinarily this would indicate that the crystal was only pseudo-cubic. In the present instance, however, no departure from cubic symmetry could be detected by either goniometric or optical observations. Whether this means that the grouping [illegible] within the substituted sulpho[illegible] not partake of the total cry[illegible] whether these groups [illegible] tain symmetrical arran[illegible] a large unit containi[illegible] be told from the exis[illegible]

[4] Wyckoff, R. W. G., The Analytical Expression of the Results of the Theory of Space Groups, Washington, 1930, 2d Ed., p. 127.

[5] Wyckoff, R. W. G., and Corey, R. B., Am. Jour. Sci., 1929, XVIII, 437.

TABLE III

TYPICAL LAUE DATA FROM AN OCTAHEDRAL PHOTOGRAPH OF DIMETHYL ETHYL SULPHONIUM CHLOROSTANNATE

Indices	Spacing	Wave Length	Intensity
$3\bar{1}5$	2.16 Å.	0.497 Å.	v.s
$\bar{3}53$	1.95	.434	m+
$2\bar{5}4$	1.91	.426	ff
$34\bar{5}$	1.81	.488	ff
$1\bar{5}5$	1.79	.384	m
$52\bar{5}$	1.74	.482	ff
$61\bar{5}$	1.63	.426	f
$7\bar{3}2$	1.63	.472	ff

TABLE IV

TYPICAL REFLECTION SPECTRAL DATA FROM A PHOTOGRAPH OF DIMETHYL ETHYL SULPHONIUM CHLOROSTANNATE

[(111) as Principal Spectrum]

Indices	Intensity	Indices	Intensity
220	s	223	ff
440	m	224	m
111	v.s	225	ff
222	f	226	f—
333	ff	227	ff
444	f—	335	ff
113	m+	336	f
114	ff	445	ff
115	m		

THE CRYSTAL STRUCTURE OF METHYL TRIETHYL PHOSPHONIUM CHLOROSTANNATE

No success has attended attempts to prepare large crystals of $[(CH_3)(C_2H_5)_3P]_2SnCl_6$. When solutions of H_2SnCl_6 and the substituted phosphonium hydrochloride were mixed the salt appeared as a white, crystalline precipitate consisting of tiny, clear, optically isotropic octahedra. Even when crystals were formed by slow evaporation of very dilute solutions none was produced of sufficient size to yield Laue or oscillation spectral photographs. For this reason, the data are confined to those given by powder photographs alone. Such data are recorded in Table V. The spacings are the average of those obtained from the measurement of six comparison films against NaCl (Table VI). Pyknometric determination of the density of $[(CH_3)(C_2H_5)_3P]_2SnCl_6$ using benzene as the confining liquid gave $\rho_{20^\circ} = 1.48$. A unit cube having this density and $a_0 = 13.93$ Å. will contain four molecules ($m = 4.05$).

No odd order powder lines were found which had other than all odd indices, with the possible exception of the outermost one measured. Other planes might be expected from an arrangement based on the simple lattice Γ_c. It will be remembered, however, that the corresponding ammonium compound, $[N(CH_3)(C_2H_5)_3]_2SnCl_6$, which presumably has the space group T-4, gave data showing no departure from a true face-centered structure of holohedral symmetry. It seems most probable that the structure of $[P(CH_3)(C_2H_5)_3]_2SnCl_6$ is analogous, with

TABLE V

DATA FROM POWDER PHOTOGRAPHS OF METHYL TRIETHYL PHOSPHONIUM CHLOROSTANNATE

Spacing	Intensity	$\sin^2\theta$	Ratio of $\sin^2\theta$	Assigned $h^2+k^2+l^2$	Indices	a_0
1.620 Å.	f	0.04802	73.83	----	----------	----------
1.850	m—	.03684	56.65	56	123(2)	13.968 Å.
1.950	m—	.03316	50.99	51	155(1), 117(1)	13.925
2.209	m	.02583	39.72	40	130(2)*	13.972
2.338	m	.02306	35.46	35 and 36	135(1) and 100(6), 122(2)	----------
2.474	ff	.02058	31.64	32	110(4)	13.995
2.679	s	.01756	27.00	27	115(1), 111(3)	13.920
3.116	ff	.01298	19.96	19 and 20	133(1) and 120(2)	----------
3.480	f	.01041	16.01	16	100(4)	13.920
4.233	s	.00704	10.83	11	113(1)	14.041
						13.963 Å.

*A line having a slightly smaller spacing than 130(2) was plainly visible on all photographs but was too faint to be measured. Estimation would place it at $h^2+k^2+l^2=43$ and thus give it indices 335.

TABLE VI

VALUES OF a_o FOR METHYL TRIETHYL PHOSPHONIUM CHLOROSTANNATE AS AVERAGED FROM COMPARISON FILMS WITH NaCl

Film No.	a_o
1	13.921 Å.
2	13.938
3	13.927
4	13.898
5	13.973
6	13.931
	13.93$_1$ Å.

tin and chlorine atoms in substantially the same higher symmetry positions that they occupy in $(NH_4)_2SnCl_6$ but with the aliphatic carbon atoms in 4f and the general positions of T-4.

CONCLUSION

Crystals of trimethyl sulphonium, dimethyl ethyl sulphonium and of methyl triethyl phosphonium chlorostannates are cubic with $(NH_4)_2SnCl_6$, or CaF_2, arrangements of their ions. The trimethyl sulphonium and the methyl triethyl phosphonium chlorostannates are like the corresponding substituted ammonium compounds, but with somewhat larger unit cells. Though a departure from cubic symmetry could not be observed for the dimethyl ethyl sulphonium chlorostannate, no set of positions for all its atoms compatible with this high symmetry and its apparent simple structure could be found.

NEW STUDIES ON THE CHEMICAL EFFECTS OF X-RAYS

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ALTHOUGH a fairly large number of facts have been collected concerning the biological effects of X-rays, chemical research on this subject has been very meager up to within a few years. In 1925, however, Miss Chamberlain (1) showed that the reduction of potassium permanganate and of iodic acid and the oxidation of sulfurous acid took place to a very slight extent when these substances were exposed to X-rays. These experiments were merely qualitative.

Workers at the Cleveland Clinic (2) in 1927 studied the transformation of oxyhemoglobin to methemoglobin under the action of X-rays and found that, between the limits 0.527–0.754 Å.U. at least, the amount of chemical action was independent of the wave length of the radiation employed. This study was followed by an extensive investigation, by the same group of workers (3), of the oxidation of ferrous sulfate to ferric sulfate. They reached the conclusions that the chemical effect produced by a given dose was independent of the wave length between the limits 0.204 and 0.765 Å.U.; that this reaction might be used as a chemical method of measuring dosage, and that the oxidation was a secondary effect produced by activated water and dependent on the amount of oxygen dissolved in the water.

Somewhat previous to this work, Glocker (4) undertook the investigation of the action of X-rays upon iodoform in chloroform and other solvents and came to the conclusion that the observed liberation of iodine was dependent on the solvent used, and that the effect noted was a secondary rather than a primary reaction. Later a very careful investigation was carried on by the same author, in collaboration with Risse (5), regarding the action of X-rays upon the decomposition of hydrogen peroxide and of potassium persulfate. Their conclusions were that the chemical action was independent of the wave length between 0.19 and 1.54 Å.U., if only that energy which is transformed into energy of electrons is considered; that the amount of energy necessary for decomposition of hydrogen peroxide under these conditions was 70 cal. per mol, and that all of the electrons produced in the solution were active photochemically.

Günther (6) and co-workers also studied the action of X-radiation on chloroform and iodoform and concluded that HCl and HI were the primary products formed.

Reinhard and Tucker (7) have noted that exposure to X-rays over long periods of time, from 35 to 100 hours, has caused a slight inversion of sucrose both in the crystalline and in the dissolved condition. Fernau (8) made similar observations several years earlier at the same time that he observed the effect of ultra-violet and radium rays.

The action on the silver bromide of a photographic plate is very rapid and obvious to anyone who has worked with X-rays. Eggert and Noddack (9) have made a study of the quantum yield, with the conclusion that one quantum of radiation of about 0.45 Å.U. develops about 1,000 silver atoms and hence one grain of the silver bromide.

Patten and Smith (10) have reported that the action of X-rays upon ammonium thiocyanate turns the latter a dark red.

The reaction between mercuric chloride and ammonium oxalate (Eder's solution) has been suggested as a convenient dosagemeter for soft X-rays by Wyckoff and Ba-

ker (11) and by Quimby and Downes (12). The formation of mercurous chloride which can be weighed occurs to a sufficiently large extent to make the reaction a sensitive method of measurement.

The study of the effect of X-rays on substances which are present in the body has been a popular field for research. Stenström and Lohmann (13) have investigated the action of the rays on certain of the amino acids and have found that while cystine underwent no measurable change, tyrosine in dilute aqueous solution is changed in regard to the phenol group. The ratio of the number of molecules affected to the pairs of ions formed is 1:12. Hussey and Thompson (14) and Clark and Northrop (15) have carried out a series of experiments on the enzymes trypsin, pepsin, and invertase, using radium and X-rays, and have found that all three of these were inactivated. Rothstein (16) also reported on the inactivation of trypsin by X-rays. The inactivation of diastase has been noted by Peskov (17). Insulin (18) is thought to be unaffected by radiation, while the effect on cholesterol seems to be the subject of a difference of opinion. It is destroyed in a medium of chloroform or carbon tetrachloride, but is apparently unaffected in a medium of benzene or carbon disulfide (19) when subjected to radiation. This action is undoubtedly indirect following the formation of oxidizing substances and the effect on cholesterol in the blood is probably very small.

Many of the investigations cited above were carried on simultaneously with this research, while very few of them date back more than three years. The subject of the chemical action of X-rays is evidently one of great interest to X-ray workers at present, and it is very probable that the next few years will bring many further developments in the field.

EXPERIMENTAL

1. Preliminary studies on a variety of reactions.—A number of different reaction mixtures were exposed to X-rays in order to determine what types of substances are sensitive to the radiation. In general, the procedure followed was to expose the specimen in a thin-walled pyrex bulb to polychromatic radiation from a tungsten target of effective wave length 0.24 Å.U. at a distance of eight inches from the focal spot. In each case a control consisting of a similar bulb treated in the same manner and subject to the same temperature but protected from the radiation by a lead shield was used. The following reactions were studied:

(a) Ferrous sulfate.—A 10 c.c. portion of a solution of ferrous ammonium sulfate in 0.04 N H_2SO_4 was exposed to X-rays from a molybdenum tube for 20 hours and then titrated with 0.0101 N $KMnO_4$; 8.18 c.c. of the titrating agent were required for the exposed solution, while 5.85 c.c. were required for the blank. Inasmuch as Kailan had reported a slight reduction of ferric sulfate by radium rays a solution of this substance was exposed in order to determine if a ferric-ferrous equilibrium was reached. However, the exposure of a solution of ferric sulfate for several months to X-rays resulted in no measurable reduction.

(b) Anthracene and dianthracene.—Inasmuch as this equilibrium is very sensitive to ultra-violet light, it seemed possible that it would be affected by the shorter wave radiation. The course of any change could be followed qualitatively very easily since anthracene is soluble in xylene or phenetole, while dianthracene is insoluble and precipitates out of solution as it is formed. However, a saturated solution of anthracene in phenetole was exposed to X-radiation for 46 hours with no effect. The following experiment also served to prove that X-rays have no appreciable effect on the anthracene-dianthracene equilibrium.

A saturated solution of anthracene in xylene was exposed for several hours to ultra-violet light from a mercury arc in quartz with the result that a considerable precipitate of dianthracene was formed. A portion of the original solution of anthracene sealed in a bulb, and a second bulb containing a suspension of the dianthracene formed in xylene were exposed to about 200 hours of raying, during which time no apparent change took place in either.

(c) Fumaric and maleic acids.—Samples of fumaric and maleic acid suspended in water were exposed to X-rays. The former acid is soluble to the extent of only 0.65 gram in 100 g. at 16°, while maleic is soluble to the extent of 50 grams per 100 g. at 10°. It was thought that any change could be detected by the accurate measurement of the temperature at which each of these samples completely went into solution. Measurements of this temperature after 200 hours of exposure to radiation showed no change in either.

(d) Iodine and benzene.—A solution of iodine in benzene sealed in a bulb was exposed to X-rays. One cubic centimeter samples of this and of a similar sample unexposed were titrated with sodium thiosulfate. Results: c.c. of 0.10 N $Na_2S_2O_3$ used: unexposed, 35.70, 35.70; exposed, 32.37, 32.27.

(e) Acetone, iodine, and water.—This reaction is apparently unaffected by X-rays. The high temperature coefficient makes this reaction impracticable for study.

(f) Inversion of sugar in the presence of lead nitrate.—The presence of lead nitrate apparently aids the inversion of sugar under the action of X-rays, but the effect is probably secondary due to a change in P^H. Results obtained after 23 hours of exposure to radiation from a tungsten target tube at 75,000 volts and 4 to 5 milliamperes, lasting over an interval of one week, were as follows:

	Saccharimeter reading at 20°	pH
Sugar solution unexposed	38.8	5.8
Sugar solution exposed to X-rays	38.4	5.8
100 c.c. of sugar solution + 1 c.c. of 10% $Pb(NO_3)_2$	38.2	5.8
100 c.c. of sugar soln. + 1 c.c. of 10% $Pb(NO_3)_2$ exposed to X-rays	36.4	$4.4 < pH < 5.2$

(g) Oxalic acid and uranyl salt sensitizer.—Many investigations have been carried out as to the decomposition of oxalic acid by ultra-violet radiation with some uranyl salt present as a sensitizer. In the work of Anderson and Robinson the reaction seemed to be more sensitive to the shorter wave lengths in the ultra-violet, which suggests that the most effective frequency might lie in the X-ray region. Solutions (1) 0.1 N in oxalic acid and 0.01 M in uranyl acetate, (2) 0.02 N in oxalic acid and 0.002 M in uranyl acetate, and (3) 0.001 N in oxalic acid and 0.001 M in uranyl acetate showed no decomposition after being irradiated 24 hours with the tube operating at 60 kilovolts and 5 milliamperes.

(h) Conclusions.—The results of these preliminary experiments and others described in later sections of this paper indicate that sensitivity to ultra-violet light is no criterion for prophesying a sensitivity to radiation in the region of 0.2–0.3 Å.U. Furthermore, the reactions most affected are those which involve oxidation or reduction in aqueous solution.

The above results shed no light on the question of the physiological action of X-rays. No chemical action yet studied, with the exception of the reduction of the silver bromide on a photographic plate, and the oxidation of ferrous sulfate, is of the same order of magnitude as that change which occurs in body tissue. It is possible that some

chemical reaction sensitive to radiation, whose counterpart has not yet been discovered, may underlie physiological action, or that the latter depends on such an effect as the coagulation of a colloid. Several examples of the latter were investigated, such as the coagulation of egg albumin and of colloidal clays, which give changes of larger magnitude than those observed in the case of chemical reactions. Further studies were discontinued inasmuch as several recent papers by Fairbrother (20) have appeared on the subject.

2. *The decomposition of organic mercury compounds.*—Since it is possible that some chemical reactions may be affected by secondary radiation from heavier metals, several aromatic mercury compounds were subjected to X-radiation, both in the solid state and dissolved in organic solvents. No change was observed after 12 hours of raying except in the case of α-acetoxymercuri-β-methoxy hydrocinnamic ethyl ester, where mercury was liberated.

reparation of α-acetoxymercuri-β-meth- hydrocinnamic ethyl ester: Twenty- e grams of cinnamic ethyl ester were dissolved in 100 c.c. of methyl alcohol and mixed with an equivalent amount of mercuric acetate dissolved in the least water possible. After three days needles began to appear, but the reaction is slow, so the mixture was allowed to stand 12 days before the compound was purified by recrystallization from ethyl acetate.

The yellowish powder rapidly changed color within a few seconds upon exposure to X-rays.

Solution for radiation: 7.041 gm. of α-acetoxymercuri-β-methoxy hydrocinnamic ethyl ester were dissolved in a mixture of 50 c.c. of ethyl alcohol and enough ethyl acetate to make the total volume of the solution 500 cubic centimeters. Fifteen cubic centimeter samples were pipetted into the thin-walled flasks, which were then tightly stoppered and completely covered with b paper to exclude radiation within the li of the visible region.

The amount of mercury liberated was termined by placing a small piece of g foil in the flask as soon as it was remo from the lead chamber. A period of hours was allowed for any settling of particles of mercury before weighing foil again. It was established that amount of mercury liberated was prop tional to the time of irradiation, all oth factors remaining constant. Flasks prote ed from the X-radiation by lead shie showed no indication of the liberation mercury, so it was assumed that the temp ature coefficient of the reaction was t small to be determined by this method.

The method suggested by Quimby an Downes was used in measuring the quanti of radiation.

Solutions Used

1. 0.4 N mercuric chloride—

Dissolve 54 gm. of pure mercuric chloride in one liter of hot distilled water. After cooling, filter the solution into the supply bottle.

2. 0.5 N ammonium oxalate—

Dissolve 32 gm. of pure ammonium oxalate in one liter of hot distilled water. After cooling, filter into the supply bottle.

3. 0.1 N in iodine—

Dissolve 45 to 50 gm. of pure potassium iodide in 25 to 30 c.c. of distilled water in a one liter volumetric flask. In this solution, dissolve 12 to 13 gm. of pure iodine crystals, and after they are completely dissolved make the solution up to one liter.

4. 0.1 N sodium thiosulfate—

Dissolve 24.8 gm. of pure sodium thiosulfate crystals in one liter of distilled water. After it has been allowed to stand ten days, it is standardized against potassium bromate. For the actual estimation of mercury this 0.1 N solution is diluted ten or

twenty times to give 0.01 N or 0.005 N sodium thiosulfate as it is needed.

3. 1 per cent starch solution.

One gram of soluble starch dissolved in a little cold water is added to 100 c.c. of boiling water and allowed to boil for five minutes.

Equal volumes of the mercuric chloride solution and the ammonium oxalate solution were mixed just before the solution was to be irradiated. Fifteen cubic centimeter samples of this mixture were pipetted into the same flasks that had been used for the α-acetoxymercuri-β-methoxy hydrocinnamic ethyl ester solution and these flasks were placed in the same position with respect to the X-ray tube. After 5 and 7½ minutes of irradiation, respectively, the amount of mercurous chloride formed was determined volumetrically. The solutions were immediately washed with distilled water from the flasks into 50 cubic centimeter centrifuge tubes. After centrifuging for five minutes at 1,900 r.p.m., the supernatant liquid was poured off, the precipitate thoroughly mixed with distilled water, and centrifuged again for five minutes. The determination may be interrupted at this point if necessary. To continue, this wash water was poured off and the mercurous chloride dissolved by adding 1 c.c. of the iodine solution from an Ostwald pipette. When the precipitate was completely dissolved, the iodine solution on the sides of the tube was washed down by a jet of distilled water and the excess iodine titrated with the standard sodium thiosulfate solution. When the solution became light yellow, 1 c.c. of the 1 per cent starch solution was added and the titration continued until the blue color completely disappeared. In the titration of blanks, the same procedure was followed to make the loss of iodine the same.

In order to compare the absorbing power of Eder's solution with that of the solution of α-acetoxymercuri-β-methoxy hydrocinnamic ethyl ester, three flasks were filled with 15 cubic centimeter portions of Eder's solution and were placed one on top of another in the order *A*, *C*, *B* in the path of the X-rays. After they had been irradiated for a few minutes, the solutions in *A* and *B* were analyzed as before for the amount of mercurous chloride formed in each. The flasks were then thoroughly cleaned, *A* and *B* were again filled with 15 c.c. of Eder's solution, but *C* was filled with 15 c.c. of the α-acetoxymercuri-β-methoxy hydrocinnamic ethyl ester solution. After raying these arranged in the same order, *A*, *C*, *B*, *A* and and *B* were again analyzed. The difference in the amount of mercurous chloride formed in *A* and the amount of mercurous chloride formed in *B* was assumed to be proportional to the energy absorbed by the solution in Flask *C*. From Table I it seems that the absorbing power of Eder's solution and the absorbing power of the solution of α-acetoxymercuri-β-methoxy hydrocinnamic ethyl ester are the same, within the limits of the experimental error.

TABLE I

15 C.C. OF EDER'S SOLUTION IN FLASKS *A* AND *B*

60 K.V. AND 5 MA.

	Flask	Time (min.)	Blank c.c. thio	c.c. thio titr.	c.c. thio Hg	mg. Hg	diff. mg. Hg
I	A	7½	9.23	7.80	1.43	2.89	
	B	7½	9.23	8.98	0.25	0.50	2.39
II	A	7½	9.24	7.15	2.09	4.23	
	B	7½	9.24	8.55	0.69	1.39	2.84
III	A	7½	9.29	7.60	1.69	3.42	
	B	7½	9.29	8.78	0.51	1.03	2.39
IV	A	5	9.25	8.21	1.04	2.10	
	B	5	9.25	9.08	0.17	0.34	1.76
V	A	5	9.25	8.00	1.25	2.53	
	B	5	9.25	8.79	0.46	0.93	1.60

Sodium thiosulfate 0.01008 N.
1 c.c. of the iodine solution used to dissolve the precipitate.
Eder's solution in Flask *C* for I and IV.
α-acetoxymercuri-β-methoxy hydrocinnamic ethyl ester solution in Flask *C* for II, III, and V.

The Eder's solution used contained approximately 20 grams of mercury per liter, but since the solubility of α-acetoxymercuri-β-methoxy hydrocinnamic ethyl ester did

not permit the preparation of a solution of the same concentration, the solution used contained only 6.03 gm. of mercury per liter. After 15 c.c. of Eder's solution had been irradiated for 10 minutes, mercurous chloride equivalent to 4.5 mg. of mercury was precipitated. Irradiation for 14 hours under the same conditions was necessary to precipitate 4.5 mg. of mercury from the α-acetoxymercuri-β-methoxy hydrocinnamic ethyl ester solution.

Over a considerable range of voltages and filters, Quimby and Downes (12) found the amount of mercury precipitated by 840 r to be 0.58 mg. per c.c., with an experimental variation of less than 3 per cent. With the X-ray tube operating at 60 kilovolts and 5 milliamperes, from Table I, 1.76 mg. of mercury per 15 c.c. of solution was proportional to the energy absorbed by Eder's solution in 5 minutes.

$$\frac{0.117}{0.58} \times 840 = 170 \text{ r.}$$

Therefore the quantity of radiation absorbed by 1 c.c. of the solution is 34 r per minute.

Assuming that the solution of α-acetoxymercuri-β-methoxy hydrocinnamic ethyl ester has the same absorbing power as Eder's solution, 28,500 r are required to precipitate 0.293 mg. of mercury per c.c. from a solution of the organic compound. Such results indicate that a valuable new method for the evaluation of strength of bonds in organic molecules is here available to the chemist.

3. Condensations of aldehydes and ketones.—Reactions in the field of organic chemistry offer many opportunities for the study of the effects of X-radiation with the possibility that much larger changes may be observed than in the examples of inorganic compounds thus far considered. As one promising type was chosen the condensation reaction of aldehydes and ketones, particularly on account of the known photochemical reactions of formaldehydes to form sugars. Claisen and Claparède (21) prepared phenylstyryl ketone by mixing benzaldehyde and acetophenone in equal proportions, saturating with hydrogen chloride gas, and allowing to stand in the cold for 12 hours. The hydrogen chloride was then removed from the product by heating the mixture on the water bath for several hours. The ketone so produced was crystallized from petroleum ether with a yield of 32 per cent. While this reaction has the disadvantage that it will proceed without radiation, it was thought that there might be a distinct catalytic effect in irradiation. Accordingly two samples of each of the several mixtures were placed in exactly the same place, at 50°, one being entirely protected

RESULTS OF SERIES OF EXPERIMENTS

No.	Aldehyde	G.		G.	HCl	E. to G
1[a]	Benz-	15	Acetophenone	15	2 g.	1
2	4-OH-Benz-	1	Acetophenone	1	5 drops	
3	4-OH-Benz-	1	Benzaldehyde	1	5 drops	
4[b]	Benz-	30		—	1 c.c. (concd.)	
5[c]	Piperonal	5	Acetophenone	Excess	10 drops	
6	Acetal-		Acetone.—Two samples were treated in similar amount of dark red oil was formed, probably para-acetaldehyde.			
7	Salicyl-		Acetophenone.—The product formed only with ex red oil, and not chalcone, which the usual cc could not be crystallized from alcoholic solution			

[a]Benzaldehyde + acetophenone → phenyl styryl ketone ($C_6H_5CH = CHCOC_6H$
[b]Melting point of product 125°, probably stilbene, $C_6H_5CH = CHC_6H_5$.
[c]Melting point of product (both) 119–120°, colorless needles.

a control and the other exposed to X-rays from a tungsten target tube with an effective wave length of 0.24 Å. for a period of five hours.

Summarizing the results of these reactions, it may be concluded that the condensation of aldehydes with ketones is markedly catalyzed by X-radiation, while the condensation of aldehyde with aldehyde is affected not at all or to only a small extent by the rays.

4. A test of the theory of hydrogen peroxide formation in the photo-chemical oxidation of potassium iodide and the reduction of potassium nitrate.—Inasmuch as experiments by Glocker have shown that X-radiation influences the decomposition and also the formation of hydrogen peroxide, it seemed possible that the oxidations noted in aqueous solution were merely secondary reactions following the production and subsequent decomposition of hydrogen peroxide from water and oxygen. The following set of experiments was designed to test this hypothesis.

1. Two thin-walled pyrex tubes were filled with a 2 per cent potassium iodide or 0.1 *M* potassium nitrate solution. Through the following devices one was kept saturated with oxygen while the other was freed of the gas, and both were exposed to the same dose of radiation.

(*a*) One was boiled to expel oxygen, cooled in a nitrogen atmosphere, and sealed. The other was provided with an outlet into an absorption bulb of potassium iodide not exposed to the radiation, and a slow stream of oxygen or air bubbled through during the exposure.

(*b*) One was heated to 100° to expel oxygen and sealed at that temperature; the other was saturated with oxygen at 0° and sealed.

The experimental data, which are illustrated by the accompanying graph, Figure 1, revealed the following facts: (1) The decomposition of potassium iodide in the *absence* of oxygen is a straight line function of the dosage of radiation; (2) the decomposition of potassium iodide in the *presence* of an excess of oxygen takes place to a larger extent, and is not in direct proportion to the amount of radiation; (3) the decomposition of potassium nitrate is a straight line function of the dosage of radiation, and is independent of the presence of oxygen; (4) the ratio of molecules of potassium nitrate to molecules of potassium iodide decomposed by the same amount of radiation is 2.90:1.

The following conclusion might, therefore, be drawn from the data: The decomposition of potassium iodide in the first case (absence of oxygen) is independent of any hydrogen peroxide mechanism which requires the presence of oxygen. Even if the objection should be raised that a very slight amount of oxygen might have been retained by the water under experimental conditions, the direct proportionality between dosage of radiation and amount of change would indicate that the concentrations of the initial reactants do not change appreciably, a condition which is true for the water and potassium iodide but not for the oxygen. The reaction occurring would seem to be

$$KI + H_2O = KOH + I + \tfrac{1}{2}H_2$$

Though this reaction would involve a large increase in free energy, the amount of energy absorbed in the radiation is much greater. The production of hydrogen from water under the radiation by X-rays has been noted by Fricke.

In the presence of excess oxygen, however, there is a possibility of the formation and subsequent decomposition of hydrogen peroxide, as suggested by Glocker, and consequent freeing of iodine. This effect might either supplant or merely add to the reaction discussed above; in either case more iodine would be freed, and the relation between dosage and chemical change might not be

linear. This conclusion is consistent with the experimental data.

The same reasoning shows that the decomposition of potassium nitrate is independent in any case of the hydrogen peroxide formation. The reaction occurring is $KNO_3 = KNO_2 + \frac{1}{2}O_2$. This is consistent with the fact that hydrogen peroxide does not affect a solution of potassium nitrate but oxidizes a solution of potassium iodide.

Thus it is concluded that the mechanism of the formation and subsequent decomposition of hydrogen peroxide is not essential for oxidation in aqueous solutions. In certain special cases, however, it may play a contributory part in the total effect.

In connection with the above results, tests were made for the presence of ozone and hydrogen peroxide. A stream of oxygen saturated with water vapor was allowed to flow past a thin glass window which was exposed to radiation. The gas was then passed into an absorption tube containing potassium iodide solution. No trace of free iodine was found after an exposure of 15 hours, during which time 12 liters of oxygen passed the window, thus indicating that the formation of ozone, unless immediately decomposed, occurred to a negligible extent.

In order to test for hydrogen peroxide, a tube of distilled water was exposed to radiation for nine hours and opened into a solution of potassium iodide. No free iodine was detected. Glocker reports the detection of a small amount of hydrogen peroxide under similar circumstances. Inasmuch as radiation has been conclusively shown to cause the decomposition of hydrogen peroxide, it is probable that a small amount may have formed and decomposed before detection.

5. *Experiments with simultaneous irradiation by ultra-violet light and X-rays.*—Some recent evidence has been obtained in this laboratory that the physiological effects of X-rays, for example, on fungi are accentuated by [illegible] simultaneous ultra-violet irradiation; in other words, the effects of the two kinds of rays are not additive. It was then thought advisable to test this observation with inorganic substances.

Two similar quartz weighing bottles containing 12 c.c., each filled with 0.01 *M* potassium iodate, are arranged so that the light from a mercury arc lamp is evenly distributed between them. One is in the path of X-rays, from which the other is shielded by a lead screen. The temperature coefficient of the reaction is low, but the temperatures are maintained as nearly equal as possible by cooling with a stream of water or of air from two equal openings in the same nozzle. Inasmuch as there is no procedure suitable for directly determining such small amounts of iodine and potassium iodide in the presence of potassium iodate, the following method was adopted: Ten c.c. of the reaction mixture was shaken in a separatory funnel with chloroform. The chloroform layer was drawn off and the residue weakly acidified with 0.4 c.c. of *N* sulfuric acid. Under these conditions the potassium iodide and potassium iodate react to give iodine, which is extracted with chloroform. The extracts are titrated with 0.001 *N* sodium thiosulfate. In a run of three and one-half hours at 70 K.V. and 5 ma., the following results were obtained:

	U. v.	U. v. + X-rays	X-rays
C.c. of 0.001 *N* thiosulfate used	I 0.20 c.c. KI 0.10 c.c.	0.13 c.c. 0.20 c.c.	
Total	0.30 c.c.	0.33 c.c.	0.03 c.c.

In two other experiments, where the difference was measured qualitatively by the depth of color in the chloroform layer, the potassium iodide was found to be appreciably greater in the tube subjected to X-rays, while the iodine formed in the two cases seemed to be about the same with a little more perhaps in the ultra-violet alone. Apparently the effects of ultra-violet light and X-rays in this case are, within experimental

error, additive. The mechanism of this complicated decomposition as shown by the distribution between iodine and potassium iodide is evidently affected. The additive effect has been further verified more directly in the photolysis of potassium nitrate.

6. Measurement of the intensity of X-rays.—Any quantitative study of the relation between the X-ray dosage and the chemical effect produced necessitates an accurate method of measuring the dosage. An international unit of dosage was established at the International Congress of Radiology at Stockholm in July, 1928, as "the quantity of radiation which, when the secondary electrons are fully utilized and the wall effect of the chamber is avoided, produces in one cubic centimeter of atmospheric air at 0° C. and 76 cm. pressure such a degree of conductivity that one electrostatic unit of charge is measured at saturation current. This unit is called the roentgen and is designated by 'r.'"

Two types of ionization chambers are employed which tend to avoid by different methods the error caused by photo-electrons from the wall and electrodes of the chamber. One is a large chamber designed to prevent wall effects by having the walls and electrodes out of the direct beam and to fully utilize the electrons by the great distance between the electrodes. This type has been used by Duane (22), of Harvard, Glasser (23), of the Cleveland Clinic, and Taylor (24), of the Bureau of Standards at Washington. The second type is of 1 cubic centimeter or less capacity and has walls of as nearly as possible the same atomic number of air; this has been used by Fricke and Glasser (23), Glocker (25), Behnken (26) and others.

A chamber of the latter type was designed and constructed for the present research. This was turned out from Acheson graphite which analyzed as containing 0.2 per cent ash and was of a cylindrical form. The walls were 1 mm. in thickness and the capacity of the chamber was 0.999 cubic centimeter. The wall itself served as one electrode, while an aluminum wire at the center, carefully insulated from the walls, served as the other electrode.

This ionization chamber was placed in a beam of radiation and the saturation current measured with the aid of a calibrated resistance of 1.29×10^9 ohms and a Lindemann electrometer, which was calibrated with a potentiometer with the aid of a standard cell.

7. Energy relations in the photolysis of potassium nitrate by X-rays.—A study has been made of the energy relationships involved in the photolysis of potassium nitrate by X-rays. This reaction has been the subject of much study in connection with the photochemical action of ultra-violet light. The unfiltered radiation from a tungsten target Coolidge tube, operating at 105 K.V. as measured by a sphere gap and 3 ma., was used in this work. The effective wave length, measured by the Duane method, which involves the determination of the thickness of aluminum which has the same absorbing power as 1 mm. of copper, was found to be 0.236 Å. The solutions used were of 0.01 *M* potassium nitrate contained in pyrex glass bulbs which were blown with thin-walled flat sides. Intensity measurements were made of the incident radiation and of the radiation which had passed through the solution. From measurements of the total area exposed the total amount of energy absorbed could be computed. The solutions were analyzed for nitrite by the Warburg method as modified by Villars (27), using weight burets and 0.001 *N* thiosulfate.

The results of three entirely independent

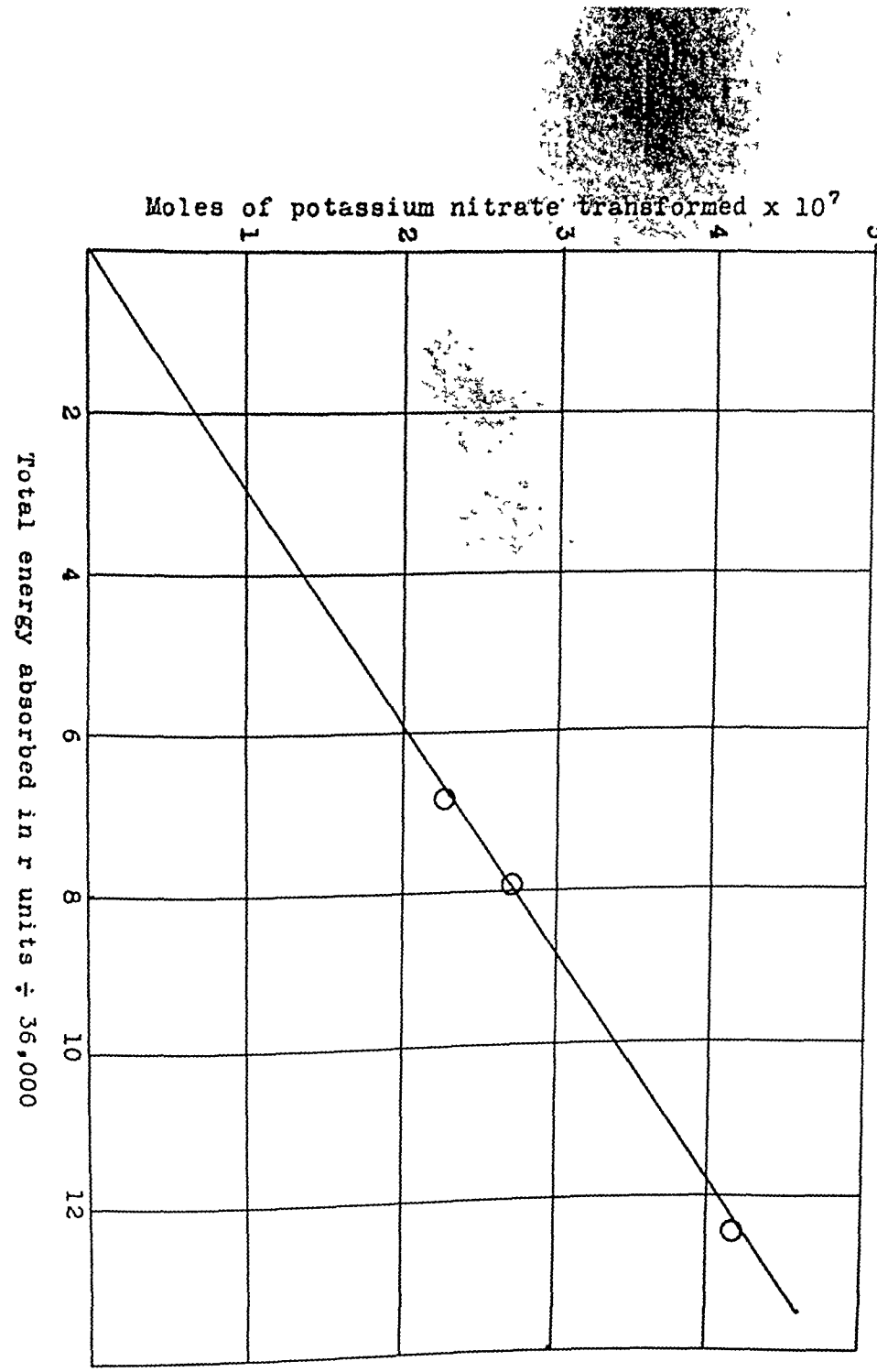

Moles of potassium nitrate transformed x 10^7
1
2
3
4
5
2
4
6
8
10
12
Total energy absorbed in r units ÷ 36,000

Fig 2

experiments, illustrated in Figure 2, are as follows:

Expt.	Exposed area (cm.²)	Thickness of layer (cm.)	Weight of 0.001 *N* thio, g.	Incident energy per cm.² per sec., r	Energy absorbed per cm.² per sec., r
1	15.48	1.62	0.4117	2.56	0.80
2	15.90	1.04	.2702	2.32	.490
3	12.91	1.12	.2291	2.40	.535

Total energy absorbed (10 hrs.)	Molecules reacting per r	Molecules per ion pair *(M/N)*	Energy cal./mole
445,680 r	5.58×10^{11}	0.2–0.3	1.31×10^{7}
280,476 r	5.83×10^{11}	0.2–0.3	1.25×10^{7}
248,400 r	5.58×10^{11}	0.2–0.3	1.31×10^{7}

Fairbrother makes the assumption that a given amount of radiation will produce approximately the same number of ion pairs in a dilute aqueous solution as are produced in the same weight of air, inasmuch as the atomic numbers of air and water are not very different. To allow for relative densities of air and dilute solution, a factor of about 1,000 is involved. If this assumption is adopted, the number of molecules of potassium nitrate which react for each ion pair may be calculated

$$\frac{\text{total energy}}{\text{charge on electron}} = \text{no. ion pairs per c.c. in air} = \frac{10^{10}}{4.774} = 2.1 \times 10^{9} \text{ ion pairs per c.c. in air, or approximately } 2 \times 10^{12} \text{ ion pairs per c.c. in the solution;}$$

$$\frac{\text{no. molecules reacting}}{\text{no. ion pairs}} = \text{molecules per ion pair}$$

Using the data given above, the values for the latter are between 0.2 and 0.3 for this endothermic decomposition of potassium nitrate. The number of molecules per ion pair may be calculated independently from the energy in calories per mole and the work required to form one ion pair (35 volts): $(1.313 \times 10^{7}$ cal./mole $KNO_3)$ / $(23{,}000 \times 35$ cal./mole ion pairs), or approximately 0.1 molecule of potassium nitrate per ion pair. This is in satisfactory agreement with the value calculated above, considering experimental difficulty, and with the order of magnitude to be expected thermodynamically.

In order to express results in terms of absolute energy, the absorption coefficients and the fraction of the absorbed energy which is converted into the kinetic energy of electrons and thence into the work of formation of ions must be known. The absorption coefficient, 0.228, as calculated from the above data, agrees very closely with the value for absorption of the same wave length in water interpolated from a series of values given by Glocker. The fraction of the total absorbed energy converted into work of formation of ions is the ratio of the values of the absorption coefficients for the energy given to recoil and photo-electrons to that of the total absorption coefficient. Using values recorded by Glocker, this fraction for the effective wave length used is 0.263.

The absorbed energy as measured in r may be converted into ergs by the use of the formula proposed by Rump (28) and Kulenkampff's (29) experimental value of 35 volts as the work required to form one ion pair in air

$$\frac{E}{i} = \frac{\epsilon}{0.36}\left(\frac{\rho}{\tau + \sigma_v}\right)$$

where $E/i = 1944$ ergs/r, $\rho =$ density, $\epsilon = 35$ volts, and $\tau + \sigma_v =$ absorption coefficient attributed to recoil and photo-electrons.

Thus the total energy absorbed in Expt. 1 is $445{,}680 \times 1944$ ergs, the fraction 0.263 of which is transformed into work of ionization. At the same time 4.117×10^{-7} moles of potassium nitrate are transformed. Thus the energy rate is 1.313×10^{7} cal./mole of reactant.

The heat of decomposition of potassium nitrate calculated from band spectra of oxygen and thermochemical data (30) is 1.03×10^5 cal./mole. Thus it seems evident that not more than 0.8 per cent of the energy absorbed and utilized in formation of ions in the solution appears as chemical dissociation of the molecule of potassium nitrate.

8. X-rays and colloidal lead.—Since the discovery by Blair Bell in England that in the treatment of cancer injection of colloidal lead followed by irradiation with X-rays materially increases the therapeutic benefits beyond those from radiation alone, there has been a great interest in the mechanism involved. There are two possibilities: that the finely divided lead produces secondary X-rays *in situ* in the tissues, or that the lead has a specific chemical effect in the tissues entirely apart from any interaction between the colloid and X-rays. In an effort to throw some light upon the mechanism, several experiments have been undertaken with colloidal lead and simple inorganic systems instead of the complex biological tissues.

Preparation of colloidal lead.—Solutions of colloidal lead were prepared in various dispersion media by the Bredig arc method, using pure lead electrodes of 6 mm. diameter held in an adjustable spark gap device. The beaker in which the colloid was prepared was surrounded by an ice-bath at all times. Some preparations were carried out in a nitrogen atmosphere. Much of the lead used was prepared by the following procedure. An arc was maintained for 10 minutes in 300 c.c. of water redistilled from alkaline permanganate, and having a P_H of 6.6 as measured by Pierre and Fudge's method. The product was centrifuged at 1,200 r.p.m. for 25 minutes and 1,600 r.p.m. for five minutes, siphoned off into containers and covered with a layer of paraffin. In some cases 0.1 c.c. of 1 per cent acetic acid was added to 30 c.c. of colloidal lead before sealing.

The colloidal lead is black in thick layers and brown in thin layers or at high concentrations. It is stable for months when protected from the air but decomposes rapidly when exposed to air to form a white suspension determined by Telkes (31) as lead carbonate. It is much more stable in a nitrogen atmosphere but decomposition is not entirely prevented. Boiling does not affect the stability. Colloidal lead is coagulated by electrolytes and is a rather vigorous reducing agent. When it is placed in a U-tube fitted with electrodes the boundaries may be seen to move toward the cathode, indicating that the particles are positively charged.

Table II (page 258) lists the results obtained in several preparations.

The method used by Telkes for analysis was followed with slight modifications. A 25 cubic centimeter sample of colloidal lead was dissolved in 0.8 c.c. of 10 per cent acetic acid. Standard potassium dichromate was added in excess and the precipitate allowed to settle. The precipitate was then filtered off, and to the filtrate and washings were added 5 c.c. of concd. hydrochloric acid and 5 c.c. of 10 per cent potassium iodide. The iodine freed was titrated after three minutes with standard thiosulfate, using starch indicator.

Effect of X-rays on the coagulation of colloidal lead.—According to Crowther and Fairbrother, positive colloids are coagulated by exposure to X-rays and consequently this effect should be noted in the case of colloidal lead. A series of experiments seemed to show that the lead was not coagulated but even stabilized to a slight extent.

1. Ten c.c. of colloidal lead was placed in each of two thin pyrex test tubes and covered with a paraffin seal. One was exposed for 30 minutes at a distance of ten inches from the target of a tungsten target tube running at a voltage of 60,000 and a cur-

TABLE II

PREPARATION OF COLLOIDAL LEAD

	Dispersion Medium	Time (min.)	Arc (amps.)	Volts	Centrifuge (Min.)	Centrifuge (R.p.m.)	Pb per 100 g. of Soln.	Remarks
1	Redist. H_2O[a]	10	2.5	40	5	840	0.04451	
2	Redist. H_2O	10	2.6	40	5	1200	.04451	
3	Redist. H_2O	15	2.8	40	20	1200	.05583	
					10	1800	.05470	[b]
4	Redist. H_2O	12	2.8	30–40	20	1600		[c]
					5	1800		[c]
5	95% Alcohol	5	2.8	35	10	1200		[d]
					10	600		[d]
6	10% Sucrose	10	2.8	35	20	1200	.05015	[e]

[a] Plus one drop of 0.1 *N* sodium hydroxide (P^H 7). [b] Some further settling out at higher rate of centrifuging. [c] 0.1–0.2 c.c. of 1 per cent acetic acid added to tubes before sealing. [d] Coagulated. Partially settled. Some remained as colloid for over a week. [e] Less stable on standing than water solution.

rent of 4 to 5 amperes, while the other (unexposed) was maintained at nearly the same temperature; 0.6 c.c. of 2.7 per cent calcium chloride was added to each and the tubes were viewed against a brightly illuminated background. Eight minutes elapsed before coagulation was visible in the unexposed, eleven minutes for the exposed.

2. The experiment was repeated using a 145-minute exposure at a voltage of 70,000; 0.4 c.c. of 0.5 per cent sodium chloride was added to coagulate and 45 minutes were necessary to obtain visible coagulation of the unexposed, while 53 minutes were required for the exposed. This result was duplicated.

3. Two tubes of lead which had been prepared for over a month were placed in the X-ray housing, five inches from the target, one protected by a lead shield, and exposed for ten and one-half hours. A slight amount of decomposition was evident in both; 0.5 c.c. of sodium chloride was added to each. In two minutes both had coagulated but the liquid in the case of the unexposed was clear, showing complete coagulation, while the other had the brown color of dilute colloidal lead, evidencing incomplete coagulation lasting for over an hour.

4. The action of rays from a molybdenum target tube operating at 30,000 volts had no apparent coagulatory effect on colloidal lead in a pyrex glass bulb 0.0035 mm. in thickness.

Secondary radiation from colloidal lead.—A very thin walled pyrex tube 7 mm. in diameter and 10 mm. in length was adjusted so that a beam of X-rays from a pinhole would pass down the length without hitting the walls of the tube. Around this a piece of film was placed in a cylindrical holder of radius 2 centimeters. A blank taken with a ten-minute exposure of the empty tube showed no effect upon the film. The film was completely blackened in a ten-minute exposure when the tube was filled with water. With the tube filled with colloidal lead, the blackening decreased with increase in distance from the point where the beam entered the column of lead and increased with time of exposure. It is evident that the intensity of secondary rays produced from the lead when measured at a given distance from the primary beam is very much less than that for secondary rays from water under identical conditions.

Effect of colloidal lead upon a chemical reaction.—The inversion of sugar was chosen for investigation because the reaction in neutral or alkaline solution has been found to be very slightly accelerated by X-rays. A series of experiments shows that the reaction is not appreciably affected by the presence of colloidal lead during the exposure to X-rays.

1. A 5 per cent solution of sugar with specific rotation at 20° of 66.5 was prepared. Tests showed that the rotation was not affected by several days' standing or pro-

longed heating at 30°. Then 25 c.c. of this solution with 2 c.c. of a 0.05 per cent solution of colloidal lead was sealed in a bulb and exposed to X-rays. A similar bulb was protected from the rays. At the end of a six-hour exposure at 60,000 volts and 2 to 5 ma., the lead was dissolved by 0.1 c.c. of N acetic acid and the rotation measured. The two readings checked exactly.

2. A solution of colloidal lead in sugar solution was made by arcing for five minutes in a 5 per cent sugar solution and centrifuging for 20 minutes at 1,200 revolutions per minute. After a four-hour exposure at 70,000 volts and 4 ma. the saccharimeter reading of 38.3 was found to be identical for the solution containing colloidal lead and the original solution similarly exposed to X-rays.

3. Colloidal lead was prepared in a 5 per cent sugar solution and a similar experiment carried out using an irradiation of 17½ hours. The following data were obtained:

Solution	Sacch. reading, 20°	PH
Original sugar solution	19.1	6.8
Sugar solution exposed to X-rays	19.07	6.8
Sugar soln. contg. coll. lead, 0.05 g. per 100 g. of soln.	19.15	
Sugar soln. contg. coll. lead exposed to X-rays	19.13	7.8
Sugar soln. contg. $Pb(NO_3)_2$ exposed to X-rays	18.85	5.6

Inasmuch as acetic acid had to be added to the lead in order to dissolve it, P^H measurements could not be made. The value given was for an undissolved portion which had been exposed to the air and had formed the white cloudy lead carbonate, which did not interfere with the colorimetric measurement but showed nothing about P^H of colloidal lead except that it was not acid.

It may be concluded that colloidal lead has no effect upon the inversion of sucrose by X-rays; a considerable effect is observed in the presence of lead nitrate, but the change in P^H alone may account for this. Hence upon the basis of these experiments the mechanism of the action of colloidal lead in the tissues seems to be the specific chemical effect, rather than the production of secondary rays. This agrees with the recent observation that colloidal gold, which should produce secondary rays as easily as lead, has no beneficial effects whatever in the Blair Bell technic.

9. *The flocculation of colloidal clays.*—The action of X-rays in flocculating colloids is an established fact. Clay solutions are usually highly colloidal. It was the purpose of this experiment to find out the action of X-rays on the clay slips. It was taken for granted that flocculation bears a direct relationship with the viscosity of the slip, that is, flocculation increases with viscosity, other things being equal.

Advantage was taken of this relationship, therefore, by first taking a measurement of the viscosity of the slip before raying, and then after raying for a certain time. The change of viscosity is a direct measure of amount of flocculation.

The viscosity was measured by means of a viscosimeter. A certain volume of the solution was allowed to drain off continuously from a large capillary, and the time recorded accurately by means of a stop watch. The following formula expresses the relative viscosity of a slip

$$V = \frac{t_s \cdot S_s}{t_w \cdot s_w}$$

where V is relative viscosity of the slip, t_s is the time required for 100 c.c. of the clay slip to flow through the viscosimeter (in seconds), S_s is the specific gravity of the clay slip, t_w is the time required for 100 c.c. of distilled water at the same temperature of the slip to flow through the viscosimeter (in

seconds), and s_w is the specific gravity of water at that temperature.

The clay slips were enclosed in 1-liter glass vessels tightly closed and exposed to radiation from a molybdenum target X-ray tube at 30,000 volts for 1,200 milliampere-hours.

The data and calculations are as follows:

1. Florida Kaolin:
 t_s = time for 100 c.c. of slip before raying to flow through the viscosimeter = 21 sec.
 t_w = time for 100 c.c. of water to flow through the viscosimeter = 12.0 sec.
 t'_s = time for 100 c.c. of slip after raying to flow through the viscosimeter = 21 sec.
 S_s = 1.210 = specific gravity of the slip.
 s_w = 1.0 = density of water.
 Relative viscosity before raying = $\frac{21 \times 1.210}{12 \times 1.00} = 2.12$, the same as that after raying.
 Hence X-rays have no effect of flocculation on Florida kaolin, which is a very pure kaolin.

2. Anna, Illinois, Kaolin:
 t_s = 25 sec. before raying.
 t'_s = 29 sec. after raying.
 S_s = 1.197.
 t_w = 12 sec. s_w = 1.0.
 V before raying = (25 × 1.197) / (12 × 1) = 2.49.
 V after raying = (29 × 1.197) / (12 × 1) = 2.90.
 Increase in relative viscosity due to raying, 16.5 per cent.

3. Tennessee Ball Clay No. 5:
 t_s = 22.5 sec. before raying.
 t'_s = 25.5 sec. after raying.
 S_s = 1.200.
 V before raying = (22.5 × 1.20) / (12 × 1) = 2.25.
 V after raying = (25.5 × 1.20) / (12 × 1) = 2.55.
 Increase in relative viscosity due to raying, 11.8 per cent.

An analysis of the latter two clays shows that they are impure kaolins containing some proteins and other organic substances; the increase in relative viscosity due to raying is a relative measure of the amount of protein substance present, since the pure Florida kaolin is entirely unaffected. Therefore, the protein is most sensitive to coagulation and affects the slips markedly even though present in very small amounts.

The authors are indebted to Mr. T. Kurosawa and to Mr. D. T. Shaw for assistance in making observations, respectively, on the condensation reactions and on the coagulation of colloidal clays.

SUMMARY

1. Several chemical systems which are known to undergo photochemical change in ultra-violet light are investigated with X-rays, in most cases of an effective wave length of 0.24 Å. Most of the changes, if any, are very small.

2. The most sensitive reactions found besides oxidation of solutions of ferrous to ferric salts are a series of aldehyde-ketone condensations, investigated photochemically for the first time. Aldehyde-aldehyde condensations are much less affected by X-radiation.

3. X-rays split out metallic mercury from α-acetoxymercuri-β-methoxy hydrocinnamic ethyl ester, 0.293 mg. of mercury being precipitated by 28,500 r.

4. The energy relations involved in the photolysis of potassium nitrate by X-rays are quantitatively determined, including an accurate measurement of intensity and dosage in r with a 1 c.c. air-wall ionization chamber. There are 5.58×10^{11} molecules reacting per r, or approximately 0.2 molecule per ion pair. The energy in calories

per mole is 1.31×10^5. Thus less than 0.8 per cent of the energy absorbed and utilized in the formation of ions in solution appears as chemical dissociation of the potassium nitrate molecule.

5. Simultaneous irradiation of potassium iodate and potassium nitrate solutions with X-rays and ultra-violet light produces additive chemical effects in contrast with non-additive biological effects on fungi, etc.

6. A thorough test is made in potassium iodide and potassium nitrate solutions of the theory that chemical effects are secondary and due to the formation of hydrogen peroxide.

7. Colloidal lead used in the Blair Bell technic for cancer therapy is studied from the standpoints of preparation, stability, coagulation by X-rays, production of secondary X-rays, and catalytic effect in reactions subjected to irradiation. The specific chemical effect rather than the action of producing secondary X-rays *in situ* in the tissues is indicated.

8. The coagulation by X-rays as determined by viscosity changes of colloidal clay slips is found to be a function of the amount of organic protein materials present.

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RADIATION SENSITIZATION, WITH CASE REPORT[1]

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ALLERGIC reactions of the body to various physical agents, including visible light, are well known, but little is found in the literature regarding similar effects produced by X-rays or radium. The following case is presented with the query: Is this a case of radiation sensitization?

CASE HISTORY

S. M. A., female, aged fifty-two, appeared January 15, 1923, for post-operative radiation for carcinoma of the left breast, at which time the following history was obtained. Her father died at seventy-six, of cerebral hemorrhage; her mother died at seventy-four of pneumonia; one sister died of typhoid at eighteen, and another of subphrenic abscess at twenty-nine; two sisters and one brother died in infancy, from causes unknown to her. She had always been well until she developed a carcinoma in the right breast, which was removed in June, 1922. A little later a gland in the right supraclavicular space was found, and extirpated. Shortly after this she developed a lump in the left breast, which was removed in October, 1922. One month later the left supraclavicular glands became painful to touch and were operated on. The pathological report showed active medullary carcinoma and adenocarcinoma of the lymph glands, with areas of necrosis. At the time of her appearance for post-operative radiation, the physical examination was essentially negative. The urinalysis showed a faint trace of albumin, and an occasional small, finely granular cast, but was otherwise normal. The blood count showed hemoglobin 90 per cent; the red cells, 4,500,000; the white cells, 5,980: the differential, 66 polymorphonuclears, 18 small and 12 large lymphocytes, 1 eosinophile, and 3 transitionals.

The patient was given deep therapy over the left thorax, through anterior, left lateral, and posterior points of entry, each with the following technic: 200 K.V., 6 ma., 50 cm. target-to-skin distance, filter 0.75 Cu, 1 Al, 20 x 20 field, time 2 hours. The left cervical glands, axilla, and breast regions were exposed, followed by a slight primary erythema, sharply demarcated over the area treated, which disappeared within twenty-four hours. There was considerable nausea for several days following the radiation. A severe reaction followed, but the skin recovered without subsequent atrophy.

A solidification of the left lung afterwards developed, and in June, 1923, a roentgenogram showed fluid in the left pleural cavity, from which 280 c.c. of a clear yellowish fluid was removed. A month later an operation was done in the right supraclavicular space, but no glands were found. The right arm was swollen and an unusually persistent cough was present. The temperature and pulse were normal. In August of 1923 chest stereograms showed a clearing of the fibrosis in the left lung. Roentgenograms of the shoulder girdles were negative for bone metastases. In November, 1923, radium was applied to the right supraclavicular glands. Two areas were treated with 50 mg. filtered through 1 mm. of brass at 1 cm. distance for six hours, and three areas in addition with the same technic the next day. Further radium was given to the right neck in January, 1924, when seven hours to each of two areas was administered. The blood count then showed: 90 per cent hemoglobin; 8,600 whites; differential, 60 per cent polymorphonuclears, 13 small and 21 large lymphocytes, 3 eosinophiles, 1 basophile, and 2 transitionals. Two

[1]Read before the Radiological Society of North America at the Fourteenth Annual Meeting, at Chicago, Dec. 3–7, 1928.

months later, twelve hours of radium, 50 mg. at 1 cm. distance with 2 mm. brass were applied in one area of the left neck. In June, 1924, the right supraclavicular region was treated over one area with the same filtration and distance. In September, 50 mg. for five hours was placed over the left neck, with the same technic. Moderate radiation sickness after each treatment was the rule.

Exactly one month from this treatment, while teaching in the classroom, the patient, who previously had been quite well, suddenly was seized with a pain about her heart so severe that she was assisted home immediately and put to bed. She became worse rapidly and was soon cyanotic, almost pulseless, and had marked difficulty in breathing. Soon afterwards, when her physician arrived, she had revived slightly. He found her pulse 120 and the temperature 103 degrees, and administered morphine and some preparation of digitalis. The cyanosis increased rapidly, so that soon the fingers and hands as well as the face were blue. She complained of feeling cold and hot water bottles were put around her. The left arm began swelling during the night, until it was twice normal in size, hard and firm to the touch, and did not pit easily on pressure. Severe itching of the skin of the chest and arms was present, and these parts became very red towards evening. Her brother, a surgeon from a near-by city who was called, reports that the urine was negative at that time. The erythema continued for three days; then her right arm began to swell and both reached such size that she could move neither. The pulse and temperature remained about the same. Vomiting was so severe throughout the attack that no food was retained. Gradual improvement from this time on was seen. The swelling in the arms began to recede towards evening, but returned towards noon the following day. One week from the onset, the arms were practically normal in size; two days later she sat up, and soon made a rapid and apparently complete recovery.

She returned November 11, 1924, for examination, feeling perfectly well, and told of her recent attack, concerning which, however, she was somewhat indefinite. It was considered that she probably had had a pneumonia, and as there were palpable glands still present in the left neck, she was given 50 mg. of radium through 1 mm. of brass, 1 cm. distance, over one area, for eight hours. She was slightly nauseated during the night, but remained perfectly well until December 8, 1924, twenty-seven days after radium was last applied. At that time she was taken suddenly ill, and had practically an exact repetition of the symptoms of the previous attack, except more severe. Her temperature rose abruptly to 107, and reached 108. There was marked swelling of all parts of the body, including the lower and particularly the upper extremities, and large wheals over the chest were present. There was severe redness and itching of the skin. The heart was greatly embarrassed, respiration was labored, with inspiratory dyspnea, and moist râles were heard over both lungs. The symptoms rapidly grew worse and no medication, including adrenalin, had any noticeable effect. She died from this most fulminating illness three days after the onset of symptoms. No autopsy was done.

The case reported suggests at least the possibility that the symptoms were the result of radiation. The literature describes the immediate effects of exposure of the body to radiation, also the local inflammatory reaction, but is very meager in describing later effects. De Courmelles, in 1924, under the title of "Radioanaphylaxis," describes a case of sensitization to radiation. Ten X-ray treatments for uterine fibroid were followed after a considerable lapse of time by a return of the symptoms, for which

another series of treatments were given. After the last series the patient had a temperature of 40° C., with nausea, vomiting, and diarrhea, accompanied by great prostration. The interval between the treatment and the onset of symptoms is not given, but the case is at least strongly suggestive of his title—radioanaphylaxis. He states that he has observed other cases of severe reaction where a long interval has elapsed between series.

Tuffier, in 1924, reported a case of radiation given over the dorsal vertebræ, from the sixth to the tenth, for metastases from carcinoma of the breast. The patient had had considerable radiation for two years previously over the left hip, vertebral column, and chest. No initial reaction followed the first series, but later vomiting for 48 hours after each treatment occurred. She was treated finally over the dorsal vertebræ, from the sixth to the tenth, and nearly a month later uncontrollable vomiting appeared, which was continuous, the vomitus containing blood. The pulse was 140, but there was no temperature. Adrenalin was administered, and the patient, who had been practically moribund, recovered. Tuffier attributed the reaction to damage to the adrenals. This case suggests a sensitization reaction, although the adrenals were exposed and probably were affected. The patient, however, recovered completely, so that marked permanent damage to the adrenals probably did not occur. The relief after adrenalin could have followed either or both.

Schmitz states that the part played by autolytic ferments in radiation sickness must remain an open question. Severe reactions, he believes, are more likely to follow irradiation over carcinomatous cervical glands than in cases of early carcinoma with few degenerative changes or with recurrent carcinoma, and he believes that the symptoms are the result of absorption into the circulation of protein liberated by destruction of cells. Acute symptoms of radiation, he states, "may come on within a few hours or may be delayed for days or even weeks." He distinguishes between symptoms of acute constitutional intoxication and those caused by injury to the tissues and organs exposed to the X-ray, which are inflammatory and occur in from fourteen to twenty-one days. The necrotic carcinoma cells in the neck, as noted by Schmitz, were present in the writer's case, and the initial sensitizing doses were certainly adequate.

Lignac, in 1924, in discussing the pathogeny of disease from penetrating radiation, says: "Cytolosis is never produced immediately after radiation; biopsy shows a modification of the radiated cells only some days afterwards, about ten to fifteen. At this time an important reaction appears, and in some neoplasms, as in the neck or mouth, for instance, an edema may be seen to appear, bringing about serious local symptoms, and also, some general phenomena—malaise, temperature, and diarrhea. These secondary phenomena are explained by resorption of destroyed cells, and from this time begins the diminution of the tumor. It is these symptoms that really constitute radiotoxemia." As Lignac states, it is logical to expect relief after adrenalin whether the patient is sensitized or not, as both conditions differ only in degree. He states, in conclusion, that "Adrenalin seems to be the rational treatment, preventative as well as curative, in this disease."

The late symptoms of radiotoxemia, as described by Schmitz, are those of absorption of necrotic proteins, and differ from those in the writer's case in that no sensitizing of the patient to previous radiation had occurred. The symptoms in unsensitized cases should be more mild because no autolytic ferments are present in sufficient quantity to produce sudden splitting up of necrotic cells, resulting in allergic shock If, however, the patient is subjected at some

time to a dose of radiation sufficient to produce extensive necrosis of tissue, then we have a sensitizing dose, which should cause ferments to be formed in sufficient quantity so that the patient thereafter becomes sensitized to further radiation. Then, any time afterwards, when cells are killed by radiation and thrown into the circulation, a rapid splitting up occurs, because the ferments are already present, and can act immediately.

The case cited presents a strong similarity to cases of allergy from other causes. There are certain factors, however, which may enter into the case, the effect of which can not be ignored. For example, the original radiation may have caused injury to the heart muscle, producing necrosis of cells and gross damage, which later may have given rise to intrinsic cardiac symptoms. R. A. Cooke, of New York City, in a personal communication, suggests that there may have been a cardiac collapse, possibly associated with hydropericarditis, but believes that the reaction in this case might well be due to a sensitization resulting from tissue damage due to radiation. He adds further that he can see no reason why involution of tissue following radiation should not give rise to a sensitization. The split products from radiation acting on the heart muscle could, he believes, have produced the cardiovascular collapse. The negative urinary findings rule out a renal basis for the attacks. Injury to the bronchi or mediastinum may have occurred for the same reason. It is, however, difficult to reconcile the symptoms which appear typical of angioneurotic edema with any of these possible explanations.

Duke has shown that the body may be sensitized to longer wave lengths of light as well as to other physical agents. This may appear either as a local or reflex-like reaction. It seems logical to expect that the shorter wave length also should produce similar reactions in the body.

Warthin states that microscopic changes in the nuclei of cells can be demonstrated twelve hours after radiation, but admits that the final death of the cell is a gradual process lasting many days. According to Simpson, the visible effects occur after radium in from seven to fifteen days, may appear within from two to three days, and in some cases may be delayed for as long a period as four weeks. The inflammatory reaction corresponds with the visible effects of radiation, but the allergic symptoms should occur only after the cells are dead and absorption has begun to take place. This will occur after the visible effects of radiation have been present, or, in fact, where no surface effect is shown, if the dose administered is small. The general experience with radiation therapy is, I believe, that the time of appearance of the visible effects after radiation depends upon the wave length used, other factors being equal. The shorter the wave length the longer the time before visible reaction appears. Hirsch states the following in his book on roentgen therapy: "The secondary erythema manifests itself after a certain time, the so-called latent period. Its duration depends upon the radiosensitivity of the cells for normal tissues. *The period is longer for rays of short wave length.*" The gamma rays of radium, being the shortest in length, should produce the longest latent period of any light rays used. Our experience with gamma rays of radium is that the visible effect is frequently present one month after treatment, although perhaps beginning to subside. Necrosis of cells, that is, actual and complete death, should occur on the average about one month after radium, so from general experience the time interval is about what should be anticipated after gamma rays of radium are used.

No predisposition of this patient to allergic reactions is known, but the eosinophilia lasting over several years is suggestive. The sudden onset of symptoms, which suggests very strongly the so-called reflex-like reactions of Duke, seems suggestive of an allergic reaction to the short light wave lengths.

The second case was a woman with a mild perineal pruritus, who was subject to asthma. She was treated during the winter-time and her asthma was summer asthma, of the hay fever type. We gave her about half an erythema in the perineal region. She came back in a few days and said that it gave her an attack of asthma. She was radiated again and came down with another acute attack of asthma. She said she would try it once more, as her pruritus was much better. We radiated her a third time and she had a third attack of asthma. We kept in touch with her—she had no more asthma the rest of the winter. These three attacks were synchronized with three half-erythema doses in the peritoneal region. It must be that there is a small amount of fairly immediate destruction of tissue because with radiation some cells, especially lymphocytes, may disappear within twenty-four hours. Then the allergic condition appears in those who are highly sensitized.

I think this case reported by Dr. Moore is extremely suggestive. His dose was much smaller than mine. The patient was evidently not so highly sensitized as were these other two cases, but I think the phenomenon of radiation allergy exists, though, fortunately, it is extremely rare.

Dr. Rollin H. Stevens (Detroit): Dr. Moore's paper on radiosensitization was a very interesting report of a case the like of which I have not seen in my practice. When Dr. Moore wrote me about this case, I studied it from every angle and tried to find some other reason than the one mentioned for the symptoms, but I concluded that it was probably really an anaphylactic shock due to the autolysis of the malignant cells and absorption which would in all probability have taken place, as Dr. Moore says, about a month later.

We have many different kinds of protein absorbed at different times during the radiation treatment, and possibly some of the early symptoms which we get after radiation treatments, such as vomiting and diarrhea (the latter immediately after deep therapy of the abdomen) are due to some chemical change in the body fluids.

Of course you remember that we get a loss of leukocytes a short time after radiation —even by the time we get through giving the first exposure we note a diminution in the number of leukocytes. Something happens to them: just what is not clear. After a week or two they begin to return. In the four-week period we note other reactions, probably due to absorption of protein matter from disintegrated cells of one kind or another, and this may in sensitive cases result in anaphylactic shock.

Dr. Alden Williams (Grand Rapids, Mich.): I thought that Dr. Moore's paper was particularly well worked up and I am quite surprised to find that such a condition as he reports may be possible. I have had telephone messages from patients six weeks after radium treatment saying that they had had a pain in the back and they wondered if the radium I had used on their face a month and a half previously could be the cause of that pain. I think that perhaps we will have to be a little careful about talking about four-weeks-later radium anaphylaxis, or we will set our public to thinking that almost anything that happens to them, except an automobile accident, may be traceable back to our treatment.

AN INTRACRANIAL CALCIFICATION, PROBABLY OF CHOROID PLEXUS[1]

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BRAIN tumors are responsible for about 1 per cent of deaths (Ewing, 1), deaths which most often occur in early or middle adult life and are preceded by great suffering. It has been possible only within recent years to treat a few of these patients with success, a success which has been attained chiefly because of the earlier localization of the tumor.

Roentgenography has contributed much to the earlier and more accurate localization of brain tumor, through the works of Schüller, Sosman, Dandy, and many others. Any further knowledge which may strengthen or clarify the diagnosis seems desirable. This paper is concerned chiefly with the occurrence and localizing value of a radiographic shadow due to calcium deposits in the choroid plexuses of the lateral cerebral ventricles.

The normal gross anatomy and histology are fully described in most text-books (Fig. 1). Each of the ventricles contains a plexus —highly vascular villous tufts, covered by epithelium (ectodermal) derived from the ependyma. The plexus occupy a relatively small space within the ventricles and are bathed by the ventricular fluid. They are attached to the ventricular wall by delicate laminæ which represent developmental infoldings of the pia-arachnoid (mesodermal) and which form a supporting framework for their many capillaries.

The choroid plexuses of the lateral ventricles, with which this paper is mainly concerned, are elongated structures, diverging slightly as they pass backward from each foramen of Monro. They lie on the floor of the body of the ventricle, and terminate a little beyond the junction of the inferior and posterior horns. The posterior extremity is expanded to a diameter of about one centimeter, called the glomus. The right and left glomus lie, one on each side of the sagittal plane, separated by a distance of about five centimeters. The glomus is the only part wherein calcification occurs in sufficient amount to produce an X-ray shadow. (The suprapineal portion of the plexus of the third ventricle may be an exception.) The pineal body, which more often casts a shadow, is exactly in the sagittal plane, about two centimeters in a frontal direction, midway between the right and left glomus.

The function of the choroid plexuses is to produce the cerebrospinal fluid. This they do, according to prevalent belief, not as secretory glands, but as semipermeable membranes (2). However, certain investigators believe the plexuses absorb the cerebrospinal fluid, while a minority believe they have nothing to do with the fluid (3, 4, 5).

Important as their function is generally conceded to be, it is somewhat striking that no disease or symptom-complex aside from tumor has been convincingly attributed to pathologic states limited to the plexuses. Yet regressive metamorphoses are so commonly present as to be considered "physiologic." These changes start in childhood, gradually increase with advancing years, becoming pronounced and characteristic in old age. They consist mainly of hyaline degeneration, connective tissue increase, and vascular occlusion. Vessels are not uncommonly found calcified (angioliths and phleboliths). Sclerotic connective tissue has been reported as partially ossified, though without calcium deposition. Hyaline concentric bodies, the origin of which is in some doubt, are of common occurrence. They are often calcified in whole or in part, and are sometimes present in extraordinary amounts. Probably these calcified concentric bodies

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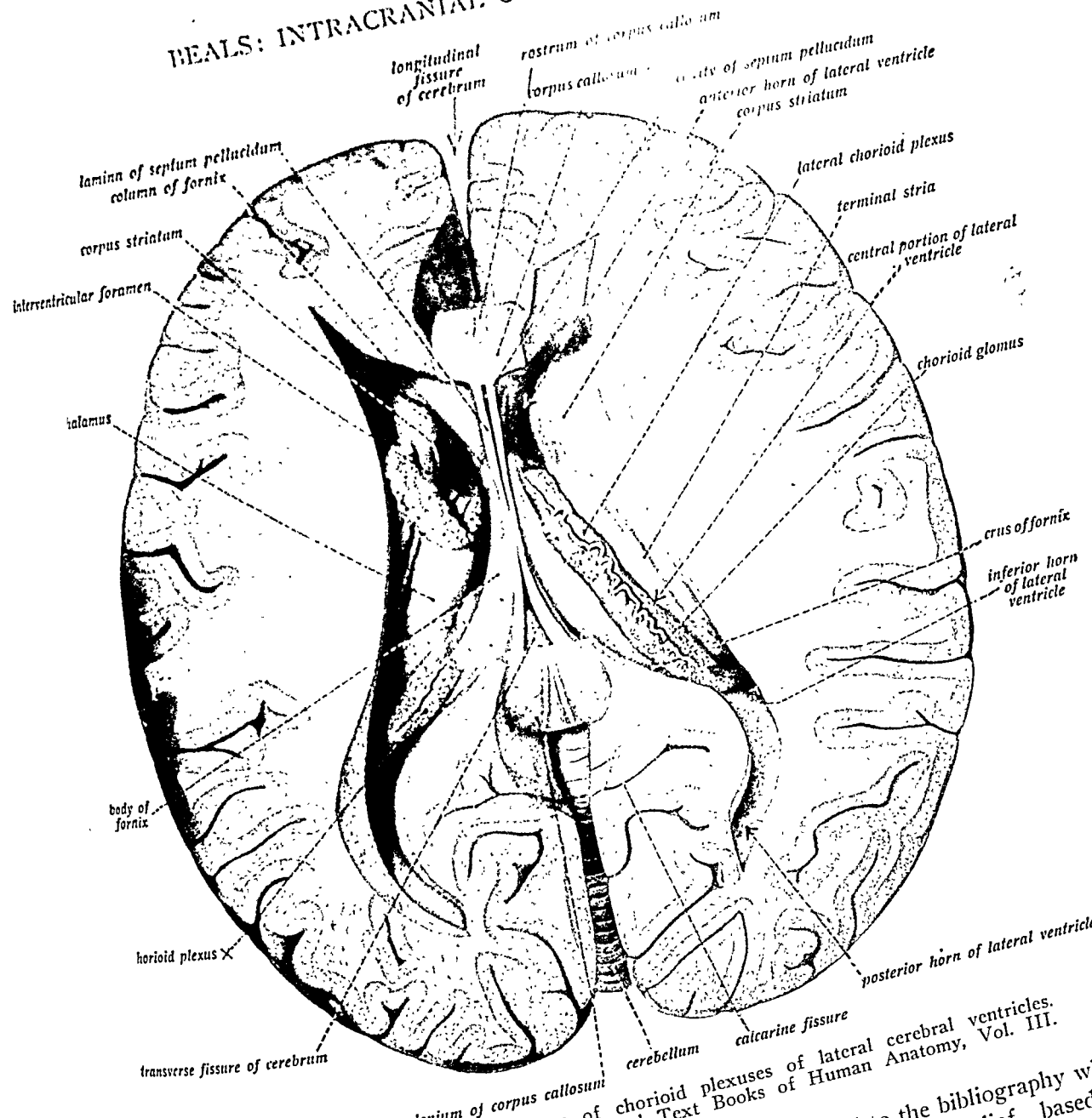


Fig. 1. Position and relations of chorioid plexuses of lateral cerebral ventricles. (From Sobatta and McMurrich, Atlas and Text Books of Human Anatomy, Vol. III. W. B. Saunders Co., 1909.)

(corpora arenacea, psammoma bodies, *sand-körper*, brain sand, etc.), with or without angioliths and phleboliths, are responsible for the X-ray shadows.

Several writers have dealt with the relationship between the pathology of the choroid plexus and various general, neurologic, and mental diseases. (For greater detail on this subject, as well as for more complete consideration of the pathology, the reader is referred to the bibliography which follows.) The general belief, based on postmortem findings, is that no clear relationship exists. This is by no means a unanimous opinion, however. As calcification in this structure is conceded to be an expression of regressive change, and is demonstrable by X-ray examination in a fairly high percentage of patients, as will be shown later in this article, the X-ray dem-



Fig. 2. Choroid plexus shadows of density plus 4. The two shadows are exactly superimposed.



Fig. 3 Choroid plexus shadows of density plus 4. The periphery of each glomus is more dense than the center. The two are not exactly superimposed.

onstration may afford a new means for selecting cases for antemortem investigation of the significance of these regressive changes.

Radiographic visualization of the two 'omus shadows has been considered rare. t was probably first recognized by Schüller (26), although Stocking's English translation of Schüller's text (27) states that the calcification cannot be shown. It was mentioned and illustrated by Heuer and Dandy (28) in their important contribution in 1916, and has subsequently been mentioned by Strom (29), O'Sullivan (30), Vastine and Kinney (31), and Murphy (32).

The writer first noticed the shadows in 1926 They were well marked in the head films of a patient suspected of having brain tumor (Fig 2) Being then unfamiliar with the shadow, a diagnosis of brain tumor with calcium deposit was made. The error was corrected by Dr W E. Dandy, to whom the patient was referred Possibly there are other roentgenologists who, through unfamiliarity, might fall into the same error. This possibility constitutes one reason for presenting the findings which follow.

The material reviewed has been selected from the files of stereoscopic head films at the Riverside Hospital. Eighty-six cases have been considered technically satisfactory. All are white adults above the age of twenty years. It has been a surprise to find the choroid shadow demonstrated twenty-four times (about 28 per cent) in this series of 86: once exceptionally well; six times very well; eleven times less well but clearly, and six times faintly. In general, the more plainly visible shadows occur in the older patients, and in those with the most pronounced pineal shadow, although there are several exceptions. The average age of patients with choroid shadow was forty-eight and three-tenths years; the youngest twenty-five (plus 2); the oldest seventy-six (plus 2). Eighty-seven and five-tenths per cent have a demonstrable pineal shadow. Sixty-two and five-tenths per cent were males, 37.5 per cent females. Of 62 cases not showing the choroid shadow, the average age was thirty-five and



Fig. 4. Chorioid plus shadow of density plus 3, showing relation to pineal.



Fig. 5. Oblique antero-posterior projection, retouched to show triangular relation of the pineal and the two glomus shadows.

five-tenths years; the youngest twenty; the oldest seventy-one. Sixty and six-tenths per cent had a demonstrable pineal. Fifty per cent were males and 50 per cent females For those patients showing the choroid shadow there was no correlation between the clinical condition and the occurrence of the shadow.

The technical factors used in these 86 cases were nearly always as follows: Curved Bucky diaphragm; 10 milliampere radiator type Coolidge tube; 4 to 5 inches spark gap; 30 inches target-film distance; double intensifying screens; "superspeed" film; exposure time varying between 15 and 25 seconds; stereoscopic right and left lateral projections, and occasionally stereoscopic oblique antero-posterior (Towne position) projections. These factors, it is believed, bring out a maximum of detail, a belief which is confirmed to some extent by a series of 62 head examinations made at the Duval County Hospital, where a flat Bucky diaphragm, 30 ma. tube, and 25 inch distance are in use. In this series there were but three cases showing the choroid shadows. Most of these patients were negroes.

The unexpected percentage, 28 per cent, of cases showing the two shadows, naturally raised the question: Are the shadows actually produced by the choroid plexuses? Their identity was established as follows:

The brain of a negro man, age thirty-nine, was obtained at autopsy. Stereoscopic films of the removed brain showed two shadows, presumably of the choroid plexuses, in their characteristic positions. The ventricles were then opened and the plexuses removed. Films made thereafter showed the pineal shadow, but not the two shadows in question. These plexuses were examined microscopically and numerous calcified concentric bodies found.

When the shadow is well marked it is somewhat oval, about one centimeter in diameter, without very sharply defined borders The density is not uniform, the shadow giving the impression of many superimposed small dots and small curved shadows. with here and there an area without shadow

increase. When less well marked (plus one and plus two) the shadow is composed of only a few scattered dots and short curves. sometimes so indistinct as to be overlooked, unless one is searching for them. Stereoscopic vision of lateral projections resolves the superimposed glomus shadows into two, separated by a considerable distance. In oblique antero-posterior views the fainter shadows are not discernible, but in those which are designated plus three and plus four, the two shadows are seen exactly opposite each other, one on each side of the midline, and separated by about four or five centimeters. In this view, when the pineal is also visualized, the three shadows stand at the angles of an isosceles triangle, the pineal at the obtuse apex anteriorly, the two choroid shadows at the angles of the base posteriorly (Fig. 5).

Naffziger (33) and Vastine and Kinney (31) have called attention to the localizing value of the shift of the pineal shadow in a ·ection away from the site of a brain tu- ›r. Murphy (32) has emphasized the ne significance for the shift of the less mmon calcareous bodies in the falx. It is e writer's belief that since the choroid adows are demonstrable in about one out four or five adults, since they occupy nor- ally a fixed bilateral and symmetrical posi- ›n, and since their normal position in rela- ›n to the pineal shadow is characteristic it is a justifiable conclusion that any definite displacement should be apparent and have a diagnostic value comparable with that accepted for the shift of the pineal and falx.

None of the patients in the writer's series have had certified brain tumor. However, it has been felt that the presence of these shadows in a normal position, in the few cases suspected of brain tumor, has added valuable evidence against the presence of tumor.

CONCLUSIONS

1. Pathologic changes of a regressive character, often with calcification, are of common occurrence in the choroid plexuses, particularly the glomus, and have been well studied by pathologists.

2. Calcium deposits in the glomus are in sufficient amount to cast a recognizable shadow on the X-ray film in a rather large percentage of adults, 28 per cent in 86 cases studied.

3. Demonstration of this calcification suggests that postmortem investigations as to the significance of regressive changes in the choroid might be supplemented by antemortem studies of selected cases.

4. At present the shadow should be considered normal and not confused with pathologic intracranial calcification.

5. The fixed normal position of the choroid shadows in relation to each other and the pineal shadow should give them the same significance in the localization of brain tumor as the midline shadows of the pineal and deposits in the falx.

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FURTHER OBSERVATIONS ON THE DIRECT ROENTGENOLOGIC SIGNS OF GASTROJEJUNAL AND JEJUNAL ULCER[1]

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THE diagnosis of gastrojejunal or jejunal ulcer is one of the most perplexing that the roentgenologist is called on to make. The examination involves structures that have been changed by surgical intervention, and for this reason atypical operations may complicate the usual appearance and suggest a lesion when none is present. In other instances there may be doubt as to the presence of a gastro-enterostomy opening. Nevertheless, reasonably definite roentgenologic criteria for the normal and abnormal anastomosis can be established.

Moynihan and Eusterman have observed that the majority of surgical failures following gastro-enterostomy are caused by the construction of an anastomosis in the absence of intrinsic disease of the stomach or duodenum. For this reason the demonstration by the roentgenologist of normal structures is quite as important as the diagnosis of post-operative disease.



Fig 1. Normal gastro-enterostomy opening. The continuity of the gastric rugæ and jejunal markings at the anastomosis is shown



Fig 2. Ulcer crater in efferent loop of jejunum accompanied by deformity of the jejunum.

Pathologically, gastrojejunal and jejunal ulcers simulate in form the usual types of gastric ulcer, that is, mucous, penetrating, and perforating. The most common is the penetrating type, which is usually found in the suture line at the stoma, or wholly within the jejunum. The majority of the latter occur in the efferent loop and may be situated as far as 15 cm. from the anastomosis

[1]Read before the Radiological Society of North America, at the Fifteenth Annual Meeting, at Toronto, Dec 2–6, 1929.

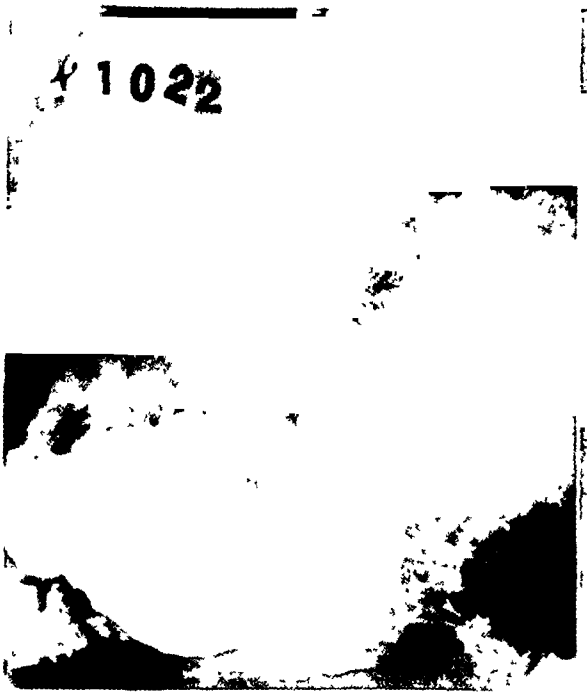


Fig. 3. Gastrojejunal ulcer producing a characteristic puckered appearance of the stomach at the site of the anastomosis. The contiguous jejunum is also deformed.

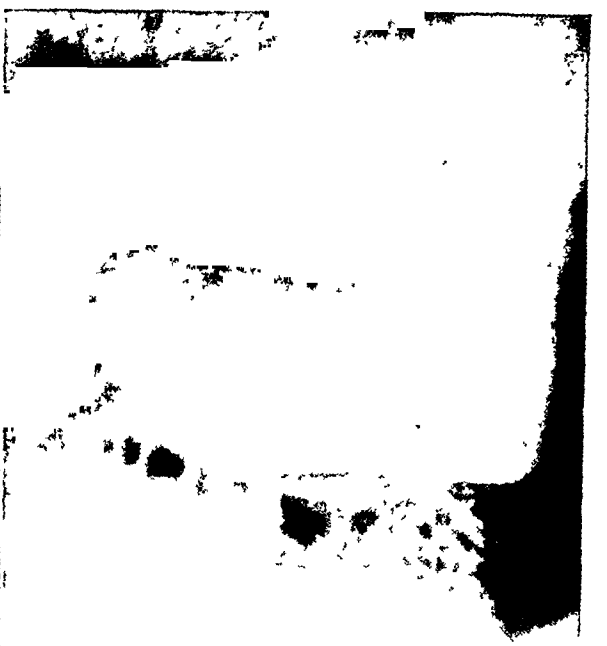


Fig. 4. Tubular appearance at stoma produced by inflammatory reaction accompanying a gastrojejunal ulcer. The obliteration of the markings of the gastric rugæ and jejunum may be noted.

Multiple ulcers are not uncommon. Jejunal ulceration is somewhat more common than ulceration at the stoma or ulceration on the gastric side. In a series observed at operation at The Mayo Clinic, sixty-one cases of jejunal ulceration were found as compared with forty-eight cases of stomal ulceration. In addition, gastrojejunitis without evidence of actual ulceration, as described by Moore and Marquis, was observed in eight cases of this series.

Interpretation of the signs of post-operative gastrojejunal or jejunal ulceration presupposes an understanding of the characteristics of the normal gastro-enterostomy opening (Fig. 1). These may present slight variations, depending on the technic of the surgeon, but as a general rule the following conditions denote a normal anastomosis: (1) the meal passes freely through the stoma; (2) there is no gastric residue; (3) the duodenal and jejunal loops are not dilated; (4) the stomach is commonly smaller than is usual without gastro-enterostomy; (5) gastric peristalsis is not overactive; (6) the stomach and jejunum in the region of the anastomosis are flexible, moderately mobile, and not deformed; (7) the markings of the gastric rugæ and valvulæ conniventes are maintained and are contiguous with each other at the stoma, and (8) the loops of jejunum are not deformed by localized or diffuse irregularity.

The direct roentgenologic signs which individually permit a positive diagnosis of gastrojejunal or jejunal ulceration are: (1) the presence of an ulcer niche; (2) persistent deformity of the stomach, stoma, or jejunum; (3) the presence of a gastrojejunocolic fistula, and (4) closure of the stoma. These conditions are best shown during the fluoroscopic examination with the patient in the upright position. The stomach should be empty and the examination should be made after only a swallow or two of the opaque meal. If all of the meal is taken at once its



Fig. 5 Localized narrowing in jejunum adjacent to stoma, with obliteration of jejunal folds in affected area Jejunal ulcer.



Fig 6 Diffuse narrowing of efferent loop of jejunum, with obliteration of jejunal folds Stomach normal Jejunal ulcer

rapid exit through the stoma, with filling of the overlying loops of jejunum, will hopelessly obscure the field. As the first portion of barium enters the stomach its descent is checked by approximating the gastric walls with pressure by the gloved right hand. This permits complete inspection of the gastric rugæ on both walls, and as the hand is moved downward, the gastro-enterostomy opening and contiguous gastric surfaces may be seen. At this point the pressure of the hand is lessened and the barium is allowed to enter the jejunum, at which time the direction of the loop can be observed. Palpation is then resumed over the jejunal area and the site of the anastomosis. During these procedures the flexibility and degree of fixation of the various parts are noted. After satisfactory inspection of the stoma and the jejunum, it is usually desirable to give the remainder of the opaque meal and to determine the patency of the pylorus and the outline of the duodenal bulb and loop In the presence of rapid emptying through the gastro-enterostomy opening, it is often impossible to express barium through the pylorus, since manual pressure only serves to hasten its exit through the anastomosis. Occasionally it may be possible to block the gastro-enterostomy opening with pressure by the left hand and then manipulate the barium through the pylorus with the right hand.

The significance and frequency of a niche or crater in the jejunum or stoma as a positive sign of ulceration is often underestimated. It represents irrefragable evidence of disease and should be sought for in each instance. It is my impression that a niche may be seen in about 60 per cent of cases The majority are found in the jejunum, nearly always in the efferent loop, and sometimes as far as 15 cm. from the stoma. The usual shadow of the niche is slightly less than 1 cm. in diameter and projects from the lateral border of the efferent loop, frequently close to the stomach (Fig. 2) Scott has stated that the majority of gastrojejunal ulcers are shown in the mesial gastrojejunal angle, which is formed by the greater curvature of the stomach and the mesial border of the efferent jejunal loop This is an interesting difference in observation, for in

my experience most of the niche shadows are found within or below the lateral gastrojejunal angle, regardless of whether the loop is made to the left or to the right. The niche invariably fills after the first swallow of barium, and will stand out as a round shadow of increased density within the stoma or as a projection from the contour of the jejunum. It frequently resembles in appearance one of the bud-like diverticula found in the colon. The niche must be distinguished from flecks of barium retained by gastric rugæ or jejunal folds. The latter can be effaced by pressure and manipulation, but the shadow of a niche will remain the same and will often become more pronounced when pressure is made over it. If the crater should empty, it will reappear at the same point, and, of course, can be found at a second examination. A niche is always accompanied by deformity of the jejunum near the site of ulceration. Multiple ulcers are not uncommon, but it is rare to observe more than one crater in the same patient.

Deformity of the stomach, stoma, or jejunum produced by the associated inflammatory reaction is the most common change accompanying a gastrojejunal or jejunal ulcer. The deformity of the stomach usually seen with ulceration at the stoma appears as puckering of the gastric contour about the site of the opening, with deformity of the rugæ (Fig. 3). In many cases in which the stomach empties rapidly, the stoma and contiguous portion of the jejunum have a tubular or funnel-like appearance, indicating inflammatory induration (Fig. 4). In such cases the continuity of the gastric rugæ and jejunal markings is interrupted in the involved area. When the lesion is wholly within the jejunum, deformity of the stomach may be absent.

Deformity of the jejunum, which is manifest as persistent narrowing, with retraction or irregularity of the normal outline, may be localized or diffuse (Figs. 5 and 6). It occurs most commonly in cases of jejunal ulcer but may be associated in a lesser degree with ulceration at the stoma. Within the deformed area the normal markings of the valvulæ conniventes of the jejunum are obliterated, due to the existing inflammatory reaction. This is a significant point of distinction from deformities due to adhesions. Localized narrowing may involve only a small area and is easily overlooked. A significant deformity will persist throughout the examination and be evident at a subsequent observation. An associated ulcer niche may or may not be demonstrable.



Fig. 7. Obstruction at the site of gastro-enterostomy, with nearly complete occlusion of stoma. Dilatation of stomach and hyperperistalsis may be noted.

In the absence of a malignant lesion, the presence of a gastrojejunocolic fistula is evidence of preceding jejunal or gastrojejunal ulceration, whether or not additional signs are present. Verbrugge, in a review of the cases of gastrojejunal ulcer at The Mayo Clinic, found that gastrojejunocolic fistula had developed in 11 per cent. Because of the high incidence of this complication and the risk attending the operation for its cure, the early recognition of the causative lesion is of considerable significance. The barium

meal should not be relied on to show a fistula, since it frequently can be discerned only by means of the opaque enema.

Complete occlusion of a previously functioning gastro-enterostomy opening in the absence of malignant disease is *prima facie* evidence of gastrojejunal ulceration (Fig. 7). It is unlikely that a normally functioning stoma will close of itself, and the experience of many surgeons supports this. Some patients are not certain whether or not gastro-enterostomy has been done, and in such instances the roentgenologist may overlook an occluded stoma. At this time the indirect signs incident to inadequate gastric drainage may suggest occlusion of a previous anastomosis. In occasional cases the inflammatory process producing occlusion of the stoma also causes obstruction of the jejunal loops.

Since a positive diagnosis is based on evidence of malfunction or the demonstration of abnormality in the outline of the stomach, stoma, or jejunum, the examiner must assume that in the beginning the gastro-enterostomy opening was anatomically correct and functioning properly. A knowledge of the surgical technic employed in the particular case is of considerable assistance.

Mechanical conditions that may mislead the examiner consist of a stoma made too small originally, a jejunal loop that is too short, adhesions, and herniation of the jejunal loop through the opening in the mesocolon The last condition is rare since the practice of stitching the edges of the opening in the mesocolon to the stomach has been adopted. The other conditions can be differentiated by the flexibility of the parts and the presence of normal gastric rugæ and jejunal markings. Their outlines may be distorted but they will not be obliterated as is the case in jejunal ulceration.

The foregoing signs have been the basis for the roentgenologic diagnosis of jejunal and gastrojejunal ulcer at The Mayo Clinic for a considerable time. The progressive improvements in fluoroscopic technic, increasing familiarity with the niche shadow, and a better appreciation of the pathologic changes and the complications of these lesions are reflected in the increased percentage of diagnostic successes. In the last two years a positive roentgenologic diagnosis of gastrojejunal ulcer has been confirmed by the surgeon in 90 per cent of cases, as compared with 74 per cent ten years ago.

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DISCUSSION

Dr. L. T. Le Wald (New York City): I would like to ask Dr. Camp what they did in the case in which there had been two operations, each followed by marginal ulcer.

Dr. Hans A. Jarre (Detroit, Mich.): This subject has been one of considerable importance in our private practice for years. It is closely related, of course, to the etiology of peptic ulcer and also to the question: What does the surgeon accomplish in the treatment of ulcer? I cannot discuss these questions here at length, but we should like at least to hear, as Dr. Le Wald has pointed out, what the Mayo Clinic does in those unfortunate cases of peptic ulcer which recur regardless of the type and extension of the resection and the type of former treatment.

Furthermore, I want to make a plea here for your support in regard to investigations. striving for a better contrast medium for

intestinal examinations. It is desirable that we pay more attention to the configuration and structure as well as the function of the mucosa. For such refined studies we need to replace the entirely non-transparent barium suspension by a semi-opaque colloid, electrically so charged that it will precipitate on the mucosa as a thin adherent coating. It is evident from the literature that experiments to find such a colloid are under way in Europe. We hope that at some future time we may be able to submit for your approval such an improved colloidal contrast medium for gastro-intestinal studies. Then the term "gastritis," which at present I dislike so much, may be resurrected, with a proper meaning.

DR. JOHN D. CAMP (closing): The patient that Dr. Le Wald referred to returned with a recurrent ulcer, and he was not operated on again. There was not much of the stomach left. The discussants have brought up the old question of the proper method of treating ulcers. This seems to be a matter for the surgeons and medical men to decide, and I prefer not to get mixed up in it.

ECONOMIC PROBLEMS OF THE X-RAY LABORATORY[1]

By PRESTON M. HICKEY, A.B., M.D., Ann Arbor, Michigan

WITH the discovery that X-ray waves would change the silver in a photographic emulsion, the users of X-ray equipment naturally made use of the photographic plates which were commercially available. The size and shape of these photographic plates had been determined from the pictorial standpoint for landscapes and groups. With the exception of the special oblong plates which were made for Dr. Charles Lester Leonard for kidney examinations, we can find no record that any attempt has been made to study the requirements of the roentgenologist in regard to the sizes and shapes of X-ray plates and X-ray films appropriate for diagnosis.

As a result there is at the present time a great economic waste in X-ray laboratories, a situation which it is one of the purposes of the present paper to discuss. A presentation of the problem seems quite timely, inasmuch as the manufacturers are at present engaged in studying the situation in regard to photographic films and photographic paper. Recently there have been many changes in the size of films and paper calculated to result in a standardization which will be an economic gain to the professional photographer.

In every X-ray examination of the adult chest the present size of 14 by 17 film is the one which is universally used. A careful study of a large number of chest films shows a waste due to the fact that the lower part of the average chest film is blank. The German economists have recognized this waste and have suggested making two exposures on the present 14 by 17 film, using a mat which will allow one of the exposures to be made of the apices, while the rest of the film can be used according to our present ideas. Such a system of double exposures, however, is inconvenient and oftentimes not needed. The greater number of chest examinations could be made on a 14 by 14 film.

The writer has calculated that in a laboratory where, say, 6,600 chest examinations are made during the year, using 13,200 14 by 17 films, there is an economic loss of considerable moment. If acetate of cellulose films are used, with a trade discount of 20 per cent, which may be taken as the average trade discount allowed to many of the laboratories, the money value of the 42 square inches of unused film is $1,716. If, in these 13,200 films, nitrate of cellulose is employed, with an average trade discount of 20 per cent, the value of the 42 square inches of film which is wasted is $1,452. In other words, in an X-ray laboratory where 6,000 chest examinations are made a year, there would be a saving of $1,700 a year if 14 by 14 films were used in place of 14 by 17. There would be a corresponding saving in developer and fixing bath. This is an economic waste which goes on year after year and on a ten-year basis the loss would, of course, be about $17,000 —money which should be diverted from the commercial trade to the treasury of the hospital or laboratory.

Another economic loss is found in the average X-ray examination of the adult spine. As the demands of the orthopedic surgeons become more insistent for X-ray examinations to include the entire spine, the problem becomes more acute. In the X-ray examination of the lumbar and thoracic spine, we usually make use of the 14 by 17 films. These are pictorially quite gratifying, but,

[1]Read before the Radiological Society of North America at the Fifteenth Annual Meeting, at Toronto, Dec 2–6, 1929.

from a diagnostic standpoint, a narrower film could be employed. It is our firm conviction that a film one-half the width of the present size is quite sufficient for spinal diagnosis. Therefore, if we are using two 14 by 17 films for the antero-posterior projection of the spine and two 14 by 17 films for the lateral projection of the spine, we are using twice as much film space as is necessary.

Coming down to a concrete basis, in a hospital where the spine examinations number some two thousand a year it follows that with the economic loss of one-half of four films of the 14 by 17 size, the following interesting figures develop. On each case there would be a loss of two 14 by 17 films. If one is using acetate of cellulose films at $0.75 apiece, that means a loss of $1.50 on each case. On 2,000 cases a year this would amount to $3,000. If the nitrate of cellulose films are used at an average cost of $0.65 apiece, the yearly waste amounts to $2,600. On a ten-year basis this would amount to the tidy sum of at least $25,000. In addition, one must always consider the saving in developer and fixing bath. If a large laboratory loses $1,500 on chest films and $2,500 on its spine films, it has a yearly loss of $4,000, and a ten-year loss of $40,000.

We can find the same lack of economy to a less extent in the use of 14 by 17 films in the examination of the femur. When one considers that the extremity films are usually made on unsuitable sizes, one might say that the waste becomes even greater than we have already figured. The present 8½ by 14 size was a mistake in the first place and is quite unsatisfactory.

Another point is the saving which would follow in the size of the intensifying screens, the cost of which is at the present time a considerable item in every laboratory. If there was a film of appropriate size for use in many of these examinations, the reduction in the annual cost of intensifying screens would result in a very considerable saving.

A great time loss occurs in laboratories where there are several X-ray machines of different types. The automobile manufacturers have finally come together and agreed on a standard gear shift which simplifies the automobile from the driver's standpoint. We see no reason why the manufacturers of X-ray machines should not get together and, in consultation with the Bureau of Standards, agree upon a standard control stand. I do not think there is any argument about the fact that consultation would evolve a control stand which could be adopted, with elimination of many arbitrary scales at present found on many switchboards, and which are confusing and time-consuming.

There is at present a lack of uniformity in the size and thickness of the cassettes which are manufactured by different companies. Some of the manufacturers are so shortsighted as to build the dimensions of some of the pieces of equipment so that cassettes of arbitrary sizes have to be used. We feel that the Bureau of Standards should, after consultation with the manufacturers, put forth a standard for sizes of cassettes. This would certainly be a source of great gratification and saving to the long-suffering buyers, who are so helpless.

Another lesson which could be taken from the automobile manufacturers is that their engineers have agreed on a standardization of nuts and screws which has resulted in great simplification in the manufacture of automobiles.

In talking with many of the service men of different X-ray companies, one realizes that a standardization of the small parts of various items of X-ray equipment could be made, with a great saving in the cost of manufacture and in the cost of service.

The writer would like to call attention to

the advantage of salvage of the silver in the depleted fixing baths. The silver can be precipitated very simply without any added complication in the routine of the dark room, and the precipitated silver can be sent to one of the reclaiming companies, that charge only a moderate percentage for saving the silver.

We would like to speak also of the uneconomic and inconvenient method of lighting fluoroscopic rooms and dark rooms. The average dark room is too dark for efficient work: the use of safe lights properly tested would give much greater illumination. Much of the wear and tear on intensifying screens and the scratching of films is caused by the dark room technician working with insufficient illumination. The method of lighting fluoroscopic rooms is also usually rather antiquated. We rely on a small ceiling light which gives no illumination where illumination is desired. When the patient comes into a dark fluoroscopic room he walks with timidity. The illumination of the fluoroscopic room should be diverted from the ceiling, where it does very little good, to the floor, so that the patient can see where he is walking. A careful study of the illumination of moving picture theaters might add much to the convenience of the patients and personnel in fluoroscopic rooms.

We would like to call attention also to the simplification of X-ray reports in laboratories. At the present time in many laboratories there is a great waste of time and paper in writing out the elaborate descriptions of normal findings. These could be filled in on suitably printed blanks and a great saving in reports could be made.

A comment upon this paper as presented so far would be that it is chiefly destructive criticism. We feel, however, that a constructive note should be added. It is suggested that representatives appointed from the various national X-ray societies should work in accord with the Bureau of Standards in Washington and with a committee from the X-ray manufacturers, to devise a program which will eliminate some of the present waste in X-ray laboratories.

DISCUSSION

DR. WILLIAM J. CASSIDY (Detroit): We have standardized everything around the hospital but the equipment which is in daily use. Inasmuch as 80 per cent of our time in the hospital is spent under brilliant illumination, why do we try to work with instruments which we can hardly see? Everything is polished up so bright, we have to focus with such sharp tension, that we are working under high tension at all times. Watch the average ophthalmologist try to do an advancement; he is dodging back and forth, trying to find a beautifully polished *bright* needle. Watch the roentgenologist with his beautifully polished centering rod. Most of your cassettes are brightly polished, reflecting light, blinding you all the time. The general practitioner, with his stethoscope, is in the same boat, and the whole group of practitioners of medicine and surgery is in very much the same position in regard to all the equipment in use. It is because someone three or four thousand years ago designed it, and we forget to change it. That is just as true in one department as another, and the sooner we realize it and try to standardize some of the equipment we are using every day and make it more useful to the man operating rather than a fit object for a showcase, the better.

DR. GEORGE E. PFAHLER (Philadelphia): We all believe in economy and we all believe in standardization, so far as it is economy, but we must not forget that standardization very often stifles progress, and when we settle down to some particular thing, it stops the next man from suggesting something new that he believes is better. Now,

for example, the illustrations that have been thrown on the screen. I make my chest examinations always with the 17 inch crosswise. That takes in not only the full chest, just reaching the curve of the diaphragm or covering the curve of the diaphragm, but also the shoulders—and very frequently you get information with regard to the axilla and shoulders which is of value. With regard to the spine—for at least fifteen years I have been taking two spine views on one 14 by 17 film, which just fills it up nicely. In examinations of the entire femur, I take two on one, either two of the same femur in different positions or the two sides, that is, the two femora on the same film. I do not believe that we need to pay too much attention to this question of films. I think the question of economizing our own time and economy of the professional time in the X-ray laboratories is of very much greater importance than the economy of the materials, with which the authorities are already annoying us enough, and I believe that we ought to be a little bit careful before we go wild on this question of economy of materials.

DR. HICKEY (closing): I have three slides which I neglected to show. One shows the average chest on a 14 by 17 film, and the three inches at the bottom which are not used—that space is now wasted on every one of the chest films you ordinarily make. Next you have a 14 by 17 film used for examination of the lumbar spine. The space between the two white lines is 7 inches wide—amply sufficient to display all the structure of that spine. Most of the space outside of the white line is simply waste film. Every once in a while we want to use a 14 by 17 film for the femur because the other films are not long enough—and we have a beautiful white space outside these lines which is simply waste film. So we go on year after year buying films that we do not use for diagnostic purposes, and putting up with them. We do not seem to have the "intestinal fortitude" to tell people what we want.

THE WORK OF THE COMMITTEE ON THE COST OF MEDICAL CARE[1]

By ARTHUR C. CHRISTIE, M.D., WASHINGTON, D. C.

THE Committee on the Cost of Medical Care was created a little over two years ago to study the causes underlying an apparently widespread dissatisfaction with the present system. This dissatisfaction is evidenced by complaint on the part of the public that adequate medical care is beyond the means of a large percentage of our population not in the charity class, and also on the part of physicians that their average incomes are not sufficient.

It is generally admitted both within and without the medical profession that the question is an important one, for which a solution must be sought. It is also admitted that the task of finding the proper and adequate solution is a difficult one, and that any solution offered should be based upon a careful consideration of all the underlying facts. It was with this in mind that the Committee was organized to represent every class which may be affected by any proposed changes in the present system. It now has forty-six members, fourteen of whom are private practitioners of medicine, six are engaged in public health work, nine are representatives of hospitals, nursing, dentistry and various special interests; five are economists, and twelve represent the general public. The vital interest of the medical profession in the entire problem of investigation and in any proposed solutions is recognized by the Committee. The profession is represented not only by the fourteen medical practitioners mentioned above, but by twenty-three other members of the profession who are in public health work, superintendents of hospitals, deans of medical colleges and in various other administrative positions in institutions.

The American Medical Association is represented by its President and its Secretary. The Chairman of the Committee is the Hon. Ray Lyman Wilbur, Secretary of the Interior in President Hoover's Cabinet and formerly President of the American Medical Association.

Under the direction of this widely representative Committee a full-time Research Staff is carrying out the projected studies. Dr. Harry H. Moore, author of the well-known book, "American Medicine and the People's Health," is the Director of Study and head of the Research Staff. The Staff is made up at present of six persons, who were carefully chosen for their training and experience along various lines. One is head of a department of sociology; one an associate professor of public health; one an instructor in economics; one an executive secretary of a western city club engaged in municipal surveys, and one is a statistician.

The program of the Committee was adopted after detailed study, on Feb. 13, 1928, and, with a few later additions, contemplates approximately twenty-eight separate studies. Eight of these are concerned with "preliminary surveys of data showing the extent of disease and disability requiring medical services and of general existing facilities for dealing with these conditions." Eleven are studies on the cost to the family of medical services and the return accruing to the physician and other agents furnishing such service. Nine are "analyses of specially organized facilities for medical care now serving particular groups of the population." The program is laid out for a five-year period, which, in view of the impor-

[1] This is not an official publication of the Committee on the Cost of Medical Care. Any opinions expressed are those of the author alone.

Read at the Fifteenth Annual Meeting of the Radiological Society of North America, at Toronto, Dec. 2-6, 1929.

tance of the problem and the extent of the necessary studies, is none too long.

A recital of only a few of the subjects which are being studied and which, in the judgment of the Committee, are necessary, will give some idea of the scope of the investigation. *Study 1* is a compilation of existing material, giving the extent of illness and of physical and mental defects prevailing in the United States. *Study 4* is a survey of statistical data on medical facilities in the United States. *Study 5* consists of surveys of medical services in several large cities, small cities, and rural communities. *Study 6* is on the cost of sickness, during a 12-month period, among various representative population groups, including the incidence of sickness. *Study 6-b* is on the cost of living in the United States, including detailed information regarding expenditures for medical service. There are studies on the cost of irregular types of medical practice; the service of pharmacy; the cost of dentistry; the cost of hospitalization; various studies on capital investment of physicians, dentists, and hospitals; pay clinics and group clinics; existing applications of the insurance principle to illness; hospital service for patients of moderate means, etc.

It will be recognized, therefore, that the Committee on the Cost of Medical Care is engaged in an extensive study of the economic aspects of the care of the sick and the prevention of illness. It is essentially a fact-finding committee. It is not committed to any theories nor has it even at the end of two years of study any solutions to offer. It hopes that at the completion of its studies it will have the facts with regard to several fundamental questions, namely, "the extent to which the burden of the cost of medical care and the incidence of sickness fall upon various economic and social classes in various types of communities; the proportion of the cost of medical care in typical communities borne by the patient, the community, and the physician himself; the financial returns to physicians, and the comparative adequacy and economy of medical care under diverse plans and diverse programs of emergency or distributed payment."

It is apparent that this problem is part of the much larger problem involved in the adjustment of individuals to rapidly changing economic and social conditions. It is comparable to the conditions that arose a few decades ago when new inventions and sanitation made a revolution in the style of living of the great mass of laboring people of this country. Before wages could be adjusted to meet the new demands there was widespread unrest among the working classes. It was the day of the cry for "a living wage," meaning, by that, a wage that would enable them to have those comforts in their home which were, only a short time before, the luxuries of the rich, but which had become the necessities of a changed style of living. This is part of the problem that hospitals are struggling to solve to-day: accommodations and general care are demanded of a far higher grade than was necessary a generation ago. Therefore, in seeking solutions for the present problem it should be borne in mind that since the year 1913, which is used as a normal for purposes of statistical studies, there has been an increase in the general cost of living of which the cost of the care of the sick is only a part. There is no evidence to support the view that hospital costs or physicians' charges have increased disproportionately to the cost of other commodities that enter into modern living. Along with the general improvement in living conditions has gone a tremendous advance in medical knowledge. The methods of diagnosis and treatment of disease have become more numerous and more complex and require expensive and complicated apparatus. Due to these and other causes, the cost of medical care has actually increased. Better accommodations are provided and more skilled workers are engaged in the care of the sick than was

formerly the case, for all of which someone must pay. The real problem is, "*Who* shall pay for it?"

When the facts are all at hand it seems quite likely that the Committee will be able to offer suggestions that will at least assist in solving some of the secondary problems that enter into the present cost of the care of the sick. Among these are the following:

(1) How can rural communities receive the benefit of modern advances in medicine?

(2) How can the present waste be eliminated, occasioned (*a*) within the medical profession by poorly qualified general practitioners and poorly trained specialists, and (*b*) among the laity by employment of quacks, self-medication, and insistence upon unnecessary types of treatment and hospital accommodations?

(3) How may all the various kinds of necessary medical service be most efficiently organized for the delivery of adequate medical care, so that individual, group, and institutional agencies may occupy their proper places?

(4) How far can governmental or industrial agencies enter into the problem without weakening or destroying individual initiative in the medical profession, or interfering harmfully with the individual contact of physician and patient?

(5) What improvements can be made in hospital construction and management which will lower the cost of hospitalization?

When the above more or less secondary questions are dealt with in some manner, there still remains the main problem. If all of the above problems were solved perfectly, the solution would operate to make slight reductions in the total cost of sickness, but it would not be of any appreciable benefit to those individuals of moderate means who face unusual and unprepared-for expenses because of illness. The question would still remain, "Who is to pay the expenses incurred for illness among people of moderate means?" The rich pay their own expenses and the community cares for the indigent. In a general way there are only two answers, either the sick must pay their own expenses or the expense must be distributed to other members of the community. Experience shows with fair conclusiveness that there are large numbers of instances in which, because of the type of sickness or injury or its long continuance, the patient of moderate means cannot himself meet a reasonable expense for adequate care. It seems necessary to devise some means of distributing the expense. The physician himself has attempted to distribute the expense among his own clientele by requiring the well-to-do to pay larger fees than do persons of moderate means. By so doing he has subjected himself to much criticism for having different prices for the same service. It is also an almost universal practice among physicians not only to do a large amount of pure charity work, but to reduce or cancel the charge in many cases in which the patient has a small income. The physician himself thus assumes part of the financial burden of caring for the sick in families of moderate incomes. These attempts of the physician to distribute the cost of medical care are unsatisfactory: (1) to the physician, who has to assume part of the bill himself; (2) to the well-to-do, who are paying part of the bill through larger fees to the physician, and (3) to the person of moderate means, who is often placed in the embarrassing position of asking partial charity of his doctor.

The Committee on the Cost of Medical Care hopes that its study will point out a more satisfactory method of distributing the cost of medical care of the people of moderate means, who, after all, constitute the bulk of our population. Among the various methods advanced, the Committee has as yet no opinion as to which is the best. It is well aware that the medical profession is almost unanimously opposed to any system

of state medicine on the grounds that it weakens individual initiative among physicians and interferes with those close individual relationships which have always existed between patient and doctor. It seems obvious, however—and is already working out in practice—that the great field of preventive medicine should be largely a function of the government—municipal, state, and national—and that the cost should be distributed among all the people by taxation.

A part of the Committee's investigation concerns itself with those large industrial corporations that are furnishing complete medical care to their employees. It will have an extensive study to offer along this line in the near future.

The Committee is also studying the attempts now being made to apply the insurance principle to cover the costs of medical care. There have always been great difficulties in the application of this type of insurance, but it is not likely that they are insurmountable. If some form of health insurance could be worked out for people of moderate means that would pay at least a large percentage of the expense incurred by sickness and that would permit the patient to choose his own hospital and his own doctor, such a system could be put into practice with the minimum of opposition.

It seems probable then that the final recommendations of the Committee will be concerned only partly with an attempt to reduce the cost of medical care. If its investigations shall lead to more thorough cooperation among all of the agencies that care for the sick and thus eliminate waste, if they point to better methods of prevention of disease and injury, if they assist in ridding the medical profession of poorly qualified practitioners and untrained specialists, if they lessen the number of persons who apply to uneducated cultists of various types, if they can bring about more economical construction and management of hospitals, and if they can indicate the limits to which governmental and corporation control of the practice of medicine may be put into force without interfering with medical progress, in so far will their recommendations be of use in lessening the cost of medical care.

As individuals, however, we are not so much concerned with a general reduction of the cost of sickness that affects us only indirectly. We are particularly and vitally concerned with our own individual problems, when we are faced with large and quite unforeseen expense brought about by sickness. The real problem in the end will be to show the great mass of people of moderate incomes some method or methods by which they may pay for what they are already receiving. It is futile to publish magazine articles berating the medical profession for the sins of a few charlatans or profiteers among them, or, on the other hand, to blame the public because it pays more for the super-luxuries of the day than it does for medical care, and for not saving money for sickness which it can not possibly foresee. The problem is an economic one. It can be solved satisfactorily only after all the facts are at hand and have been analyzed so as to give them their proper relative values. The Committee looks upon this as its task and hopes that at the conclusion of its investigations it will have sufficient data to enable it to present constructive recommendations.

DISCUSSION

DR. HARVEY AGNEW (Toronto, Canada): I have enjoyed exceedingly hearing this paper, and I must congratulate the author upon the lucid manner in which he has outlined the problems that are now facing this Committee on the Cost of Medical Care. We have been following the various announcements of the Committee and members of the Committee with great interest, because we realize that many of the problems which you are

facing in the United States are problems very similar to those which we have to face here in Canada and feel should be studied thoroughly by our organization, the Canadian Medical Association. We have the same difficulty that you have, namely, a number of journals publish articles berating the medical profession, berating the hospitals, and giving the impression that everyone who looks after the sick is more or less obtaining all that the traffic will stand. It is particularly unfortunate that the public, through magazines and occasional newspaper articles, should be given this impression, because it is decidedly unfair to many of our hard-working, unselfish doctors, and our devoted hospital workers, who are spending so much of their time in helping the public, very often without thanks for services gratuitously given.

Here in Canada we have been studying this question and undertaking various experiments along the lines suggested for study by Dr. Christie; for instance, national health insurance has been made a point of study by the Canadian Medical Association and all the various affiliated provincial associations. In the Province of British Columbia, on the Pacific Coast, they have made a most intensive study, and the Government of the Province has now a commission which is going into this question thoroughly. We have, on the prairie, a large number of municipal hospitals organized and financed by the people in the rural communities and giving these subscribers reduced rates. A "ticket," or subscriber system, prevails in certain areas in the Maritime Provinces and in Saskatchewan. We now have a maternity allowance of twenty-five dollars which helps the mother at that particular time. In Ontario we have a Royal Commission on Public Welfare which is studying hospital costs, hospital organization, hospital management and all of the many details which go to contribute to the hospital factor in the cost of medical care. We have a joint committee of the Canadian Nursing Association and the Canadian Medical Association studying the nursing question to see if something can be done to make this great branch of the healing profession of still greater service to the public and at less cost to them, at the same time safeguarding the income of our nurses.

On January first, the Canadian Medical Association will start a new scheme of periodic health examinations. In this we are aided by the insurance companies, who are permitting the general practitioners of Canada through the Medical Association to examine what ultimately may be practically all of the policy holders in the various insurance companies. This will be a periodic check-up done by the doctors themselves, the patient being referred back to *his own family physician* for this examination. We feel that this will be a great step forward in prevention of disease and therefore a means of lowering the cost of illness to the nation. I was pleased to hear Dr. Christie outline some of the main considerations that must be borne in mind if some form of health insurance is to be introduced. Here our own opinions are rather divided upon that question. As yet there is no unanimity, but we have made as intensive a study of this as possible, and this study is still going on. We feel that it is not wise to stampede the public and our legislators into such a drastic change in our system of caring for the public. There are many points to be considered; we would hope that, if such a scheme were introduced, it would work for the benefit of all, but we do not want to go "from the frying pan into the fire." Therefore the motto of organized medicine has been that of watchful preparedness. We are prepared to offer the advice when and if it be requested, but we do not feel like urging a nebulous measure with its ill-defined powers for good or for evil. I think that the majority of our students of this question feel that if, at any time, we have

some form of national health insurance, it should embody certain very definite stipulations. For instance, we feel that it is highly essential that the patient have the right to choose his or her own physician. We also feel that it is very essential that the doctor be paid for services rendered and not upon a *per capita* basis, such as is frequently done in lodge practice. We wish to avoid some of the pitfalls that have bothered the medical profession in England during the last decade. We feel that any form of health insurance of this type should include the whole family, not only the breadwinner. We also feel that the insurance should cover not only the cost of medical attention, but should cover the hospital cost, nursing cost, and all laboratory expenses, such as pathological examination, X-ray examinations and the like. Also, if any such form of insurance is to be introduced, it should be of a compulsory nature so that we do not have the ones who are likely to need it coming in and the ones who are in good health staying out; it should be compulsory for all people who are below a certain salary or income. We are all waiting, in this country, with a great deal of interest for the final report of the Committee on the Cost of Medical Care.

THE PRE-RADIUM TREATMENT OF CARCINOMA OF THE UTERINE CERVIX[1]

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MOST surgeons and gynecologists are now agreed that once a definite diagnosis of uterine cervical cancer has been made, the case is one for radiation treatment, with the possible exception of the infrequent Stage I growths, in which surgery or radium may be used with equal success.

EXAMINATION

The patient should first be carefully examined, not only to determine the extent of the local disease but to ascertain the general condition. It is especially necessary to ascertain if any metastatic malignancy is present, and if the patient is in condition to receive radium treatment. It is important that the gynecologic examination be done gently, as rough examinations have a tendency to disseminate the disease. Upon the results of the gynecologic examination, the patient should be classified as having a Group 1, 2, 3, 4, or 5 cervical cancer, in accordance with the classification of Schmitz. In making the gynecologic examination, it is important to determine if the uterine canal is patent, and if so, to ascertain and record its length (by means of a sound). A biopsy of the lesion should be taken at this time. Biopsy carries insignificant hazards in cervical cancer because the lymph and blood channels are already blocked by the ulceration that is invariably present.

CLASSIFICATION OF PATIENTS

Before considering the method of treatment in a particular patient, it is well that the growth present be classified, in order to provide a convenient means for discussing the therapy. A classification that has proven popular in this country is the one proposed by Henry Schmitz, which is quite simple, and based entirely on the local physical findings. The carcinomata are divided into primary and secondary or recurrent. The factors which determine the grading of the primary carcinomata are as given in the following grouping.

Group 1 comprises the earliest lesions, which, unfortunately, are the least frequently seen. The growth is the size of a navy bean, is clearly localized within the cervix, and the uterus has normal movability. (A uterus normally movable can be displaced downward without causing distress to the patient or the use of an unusual amount of force, until the cervix appears at the vaginal outlet when pulled by a tenaculum forceps attached to the cervix.) This group is sometimes called "operable."

Group 2 includes cases in which there is a wide or peripheral invasion of the cervix or body of the uterus, a doughy consistency of the paracervical tissues, and decreased mobility (evidenced by failure of the uterus to be completely displaced downward when pulled by a tenaculum forceps). This group is often called "doubtfully localized" or "borderline."

Group 3 includes cases in which there is infiltration of one or both parametria, with or without regional lymph node involvement or invasion of adjacent organs, but the structures are, as a mass, still movable, though elasticity of the tissues is lost. This

[1]Read before the Radiological Society of North America, at the Fifteenth Annual Meeting, at Toronto, Dec. 2–6, 1929.

group is sometimes called "advanced" or "inoperable," and is the condition most commonly present when the patient presents herself for radiation treatment.

Group 4 cases are characterized by absolute fixation of the tissue (the "frozen pelvis"), wide local extent of the disease, and usually distant metastases. This group is often called "terminal," "fixed," or "inoperable." The "complicated" carcinoma is one associated with general disease in a patient who is considered a poor surgical risk.

The characteristics of the groups in the recurrent carcinomata are: *Group R 1* contains the local but normally movable recurrence; *Group R 2,* the regional but movable recurrence; *Group R 3,* the cases with local and regional movable recurrences, and *Group R 4,* the recurrence, with fixation of the mass.

Since the use of radium in uterine cancer is a hospital procedure and the patient is not acutely ill, there frequently occurs some delay until consent has been secured to proceed with the treatment. Many women will delay some weeks "getting ready" to go to the hospital. What treatment should the patient receive in the interval? Should the physician administer no treatment in uterine cervical malignancy until radium is actually applied?

It is a fact that the majority of patients suffering from cervical cancer, when first seen by the physician, already present an advanced stage of the disease. Schmitz, in his analysis of 332 primary cases, found that 49 per cent had Stage III growths when treatment was first begun and 30 per cent had Stage IV growths—a total of 79 per cent advanced lesions. Other writers report statistics in about the same proportion.

CONTRA-INDICATIONS FOR RADIUM

Recently Strachan has enumerated seven contra-indications to the application of radium that are well to keep in mind. These have been emphasized in an editorial in the *Journal of the American Medical Association:*

"General emaciation and cachexia is a condition that is unfavorable to radium treatment; in such cases the method is liable to result in rapid deterioration and early death. When the red cell count is below 3,000,000 or the hemoglobin index below 40, radium should not be applied; radium treatment has a tendency to produce a degree of anemia, probably by a systemic action on the spleen, and this in the presence of a pre-existing severe anemia may be dangerous. If hydronephrosis or pyonephrosis should be detected by the presence in either loin of a tender swelling, radium should not be applied; the resulting increased fibrosis in the broad ligaments will add to the obstruction. Rectovaginal and vesicovaginal fistulas are contra-indications, as radium in such cases is apt to cause intense local irritation with sloughing. Radium should not be used in the presence of any inflammatory pelvic lesion; a foul sloughing condition of the growth is one of the most common and important of these; if radium is used before the inflammatory condition has been cleared up the probable consequence is a massive necrosis with some toxemia and pelvic parametritis or peritonitis. In cases in which the whole pelvis is extensively infiltrated with extension from the cervical growth the use of radium even supplemented with high voltage roentgen therapy seems often to hasten rather than to delay the end. Finally, radium should be withheld in the presence of impaired metabolism, especially defective excretion of nitrogenous waste products. Dr. Strachan is careful to point out that some of these conditions may be overcome, and radium may then be used. One temporary contra-indication which he does not mention, the condition of pregnancy, has been emphasized of late by other writers. The risk of radium to the fetus is almost, but not quite, as great as the Wertheim operation. Even so, it may at times be necessary to sacrifice the child's interest in order to treat the mother while there is still a fair prospect of saving her life."

EXTERNAL RADIATION

When radium is applied in the uterus or vagina, its ability to successfully destroy cancer cells probably does not reach beyond 2 or 3 cm. from the walls of the applicators. It is apparent, therefore, in Stage III or IV cervical growths, that intra-utero-vaginal radium alone cannot be expected to control the condition and that additional radiation from without is also necessary. This can be applied in the form of high voltage (200,000 volts) X-ray treatment, or by means of the so-called "radium pack," by which the entire pelvis is cross-fired through a number of different portals. In such advanced cases, the question is, Should this external radiation precede the internal radium treatment or not? There appears no question but that the extra-uterine involvement is the greatest source of danger to the patient and may result in perforation into the rectum or bladder, or permit the growth to spread beyond the pelvis. It is also true that the outer limits of a tumor are usually the most active in growth. In view of the above, would it not appear more logical to administer the external radiation first?

The views of Prof. Claude Regaud, associate of Mme. Curie, of the University of Paris, who has had perhaps as wide an experience as anyone with the radiation treatment of cancer, are interesting in this connection.

Regaud believes that any attempt to reach the parametrial involvement in cervical cancer by radium needles, implants, seeds, etc., is not good practice. He contends that the interstitial use of radium in this region is dangerous. The simultaneous employment of radium puncture and intra-utero-vaginal irradiation may cause secondary rays excited by the impingement of gamma rays on the platinum needles or seeds. Such beta therapy increases the danger of radium necrosis. Regaud states that the association of X-rays or radium at a distance, with radium applied utero-vaginally, is the correct method when the parametrium is invaded. He contends that if X-rays are used to give the external treatment, they should always precede the radium treatment, while if external radium therapy at a distance is used (radium pack), it should follow the internal radium therapy.

Pack, in describing Regaud's method, states:

"The association of radium therapy and roentgen therapy is for the purpose of securing the combined action of the X-rays (in the peripheral part of the neoplastic territory) and of radium in the uterus and vagina. When the neoplasm has extended beyond the uterus (parametrium, vagina, pelvic adenopathies) this combination is the method of choice and is the rule in the majority of instances. Regaud believes that the order of succession of these two agents is not an indifferent matter. The inefficiency of the X-rays in the treatment of recurrences following previous radium therapy has been shown by Regaud (1923) *à propos* of epitheliomas of the skin and mucous membranes in general. X-rays are especially inefficient after radium therapy has been given by the utero-vaginal method. To use these agents in the correct combination, roentgen therapy should be administered first, followed immediately, or after a very short period of rest, by radium therapy."

CERVICAL INFECTION

A factor to which many American radiologists have not given proper consideration in treating malignancy is the local infection that accompanies so many of these growths. The rôle of infections in the dangers and complications incident to the use of radium is particularly important in cancer of the uterine cervix. Local infection invariably accompanies cervical cancer at the moment it opens into the vagina. The infection usually progresses with the progress of the cancer and probably does as much, if not more, to break down the resistance of the patient as does the growth itself. The infection is

at first superficial, but later extends deeply, and the infiltrations that one palpates may be due to infection, newgrowth, or both. If an attempt is not made to first control this, radium may transform the local infection into an acute pelvic cellulitis, a suppurative salpingitis, a circumscribed phlegmon of the pelvic tissue, a generalized peritonitis, or a septicemia.

The rapidity with which some physicians apply radium, immediately upon diagnosis of a cervical cancer and without any preliminary treatment, is to be condemned. A better procedure is to give copious, mild, antiseptic vaginal douches several times each day until the local infection is controlled. Pack, in describing Regaud's preliminary radium treatment, states:

"The putrefactive microbes disappear readily under this local treatment, but the pyogens, namely, the staphylococci and streptococci, are more difficult to destroy. Autogenous vaccines are responded to by the staphylococci, but the streptococci, particularly those of the dangerous hemolytic type, are very resistant. In every instance where internal radium therapy has been followed by severe pelvic infection, the preceding bacteriologic analysis has demonstrated the presence of hemolytic streptococci: on the contrary not every patient harboring these streptococci within her vagina will suffer this complication.

"The ablation or curettage of cancerous vegetations of the uterine cervix has certain advantages: it facilitates treatment; it may suppress the suppuration from the infected cervix; it frees the implantation of the cervical tumor from the orifice of the uterine canal; it permits closer approximation of the radium foci to the outlying cancer tissue; it favors cicatrization and lessens the danger of toxemia from absorption. A bleeding, infected, sphacelic, 'cauliflower' cervical tumor should be amputated, preferably by diathermo-coagulation, previous to the introduction of the radium into the vagina and uterine canal."

Kaplan, in describing the method used at Bellevue Hospital for these patients, states:

"Treatments are planned according to the extent of the lesion present. If marked ulceration and infection are present in the vagina, a course of disinfection with douches initiates the treatment. The patient is shaved and cleansed externally; the bowels are cleansed with enemas. Douching with boric acid solution or with 2 per cent glucose solution twice daily is carried out until the vagina has been cleansed thoroughly and much of the induration about the cervix reduced. Following the douching, the vagina is irrigated with 2 per cent methylene blue solution, a mild antiseptic which seems to clean up the infection more rapidly.

"Radiation is not begun until the disinfection or cleansing is completed, so that little infection is present in the vagina when the treatment is given. Meanwhile the general condition of the patient is improved by dietetic and hygienic methods. Constipation, which is present in nearly all cases, is treated by mineral oil and magnesia, and enemas if necessary."

Pinch, in describing the technic used at the internationally known Radium Institute of London, states:

"Patients suffering from carcinoma of the uterus often present themselves in a condition which negatives any attempt at immediate treatment. The cervix, fornices, and vaginal walls are extremely ulcerated, covered with washleather sloughs, and exude a constant, copious, purulent, offensive discharge. It is of the utmost importance to render the diseased surfaces as clean as possible before using radium. Douches of Tr. Iodi. drams 1 to 1 pint of warm water should be used two or three times a day, a Ferguson speculum should be passed, and any loosely adherent sloughs detached with forceps or a probe covered with cotton wool. This treatment should be persisted with until all detritus and sloughs have been removed and the discharge is no longer offensive. If the iodine douche proves unduly irritating, glyco-thymoline (1-20) may be substituted for it in the later stages. A douche of Flavine, 1 in 2,500, should be given on the day before, and early in the morning of the day on which the radium is inserted."

During this preliminary treatment the patient, if able, may be up and around. She should be thoroughly examined to determine the extent of the lesion and to ascertain if any distant metastasis is present. X-ray examinations of the chest, spine, and pelvis are valuable in ruling out metastasis in these parts—favorable areas for the growths to appear. In addition, every effort should be made to eliminate sources of focal infection and to improve the general health of the patient.

After a week or ten days of preliminary treatment, the cervical canal should be gently dilated by the use of graduated uterine sounds, and the length of the uterine canal noted. The patient is then returned to bed and her temperature taken at frequent intervals during a period of twenty-four hours. If there is no increase in temperature, the patient is ready for the internal radium treatment.[2]

PRELIMINARY RADIUM OR ELECTROTHERMIC AMPUTATION

When the cervical canal is filled with a cauliflower growth, or an ulcerating growth at the external os, and localization of the cervical canal is impossible, the patient should not be given the principal internal radium treatment. Such cases should receive preliminary radium treatment by the embedment of radium needles or implants, or the cervix should be removed by electrothermic measures.

Kaplan, Pfahler and others advocate the amputation of the cervix or the removal of malignant masses by electrothermic means immediately preceding the insertion of radium in certain cases (a small percentage) of cervical cancer—as when the cervical canal is obstructed by a large cauliflower growth blocking the vagina or there is much hypertrophy of the cervix associated with a large amount of fibrous tissue which may help to shield carcinoma cells. When such treatment is carried out, preliminary radium treatment is not necessary, as the uterine canal is rendered patent and the principal radium treatment can be readily carried out Sometimes complete removal is not possible. In such instances, as much growth as feasible is removed and then radium needles are inserted in the remaining mass. When the mass has receded the uterine canal may be located and the principal radium treatment carried out.

If preliminary radium is used, the uterine canal will usually become sufficiently patent in 10 to 20 days, to permit the introduction of an intra-uterine radium applicator. In fact, these cases usually respond remarkably to such preliminary radium treatment. There is a danger that the patient or physician may think that further radium is not necessary because the excrescences are cleared up so readily.

Preliminary radium treatment or electrothermic amputation is absolutely necessary in all cases where the growth has proliferated to such an extent as to occlude the cervical canal, if the maximum results are to be secured. The principal radium treatment should not be given until the uterine canal is rendered patent. Many radiologists are now of the opinion that the best results in cervical cancer can only be secured by treating the entire uterine canal with heavily filtered radium. This necessitates the predetermining of the length of the uterine canal, in order that the proper type of applicator may be provided. If the cervix is to be first amputated, the length of the uterine canal will be shortened and the radium therapist must consider this factor

[2]Since this paper was read before the Radiological Society, the 1929 report on "Radium Treatment of Cancer of the Uterus," of the Cancer Research Committee of the Marie Curie Clinic (London Association of the Medical Women's Federation) has been published. This report covers 300 patients treated during the previous three and one-half years. The following is quoted from the technic of preliminary preparation as used at the Marie Curie Clinic:

"The preparation of the patient includes a general examination, a blood count, and urine analysis; when necessary a cystoscopic examination is made to determine the condition of the bladder. A bacteriological examination is important. Disinfection is carried out with acriflavine douches (1 in 1,000 normal saline) twice daily for a day or two before treatment. In advanced cases with extensive necrosis and foul discharge, rest in bed for a few days and a more thorough cleaning-up is advisable In cases of severe anemia the patient is kept in bed for two or three weeks for special treatment before the radium is applied."

when constructing the intra-uterine applicator.

SUMMARY

In conclusion, the following in regard to the pre-radium treatment of cervical cancer should be emphasized:

1. Every case of advanced cervical cancer should receive external radiation and if this is given by high voltage X-rays, it should preferably precede the internal radium treatment.

2. Local infection constantly accompanies cervical cancer and no case should receive internal radium treatment until the infection has been controlled by suitable douches, etc.

3. The principal internal radium treatment should not be given until the uterine canal is patent, as the best results are secured by placing radium the entire length of the canal. If the canal is occluded it should be treated by preliminary radium until rendered patent, or the cervix should be amputated by electrothermic measures preceding the principal internal radium treatment.

4. Every effort should be made to eliminate sources of focal infection and to improve the general health of the patient.

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THE CAUSE OF DEATH FROM RADIUM[1]

By A. JAMES LARKIN, M.D., CHICAGO, ILLINOIS

WHAT might be said to be the cause of death should a patient die from what would appear to be general rather than the local effects of radium rays prompted the work discussed in this paper. The local changes brought about in tissues irradiated for clinical purposes are fairly well described and morphologically understood.

To ascertain, then, the cause of death, the following method was devised: the whole body of young rabbits was exposed to the gamma rays from radium. It was necessary first to determine the lethal dose. This having been accomplished, the study turned to the clinical changes resulting from lethal and sublethal doses and finally to the pathological changes resulting from each.

The technic consisted of placing young rabbits in a round cage twelve and one-half inches in diameter, the radium being suspended in the middle of the cage two inches from the floor. In a second series the animals were placed in a cage seventeen inches square. In the one series the distance from the radium to the farthermost part of the animal was six and one-fourth inches, in the other series this distance was eight and one-half inches. The amount of radium varied between 15 and 200 milligrams, the amount used seeming to be immaterial so long as the milligram-hours were the same. It seemed also to be immaterial whether the dosage was delivered at one sitting or more.

TABLE I

ANIMALS RECEIVING LETHAL DOSE OF RADIUM

CLINICAL OBSERVATIONS

Number	eleven young and one adult
Average age at beginning	29.2 days
Average beginning weight	480 grams
Average weight at death	441 grams
What would have been average normal weight at time of death, considering normal life expectancy	730 grams
Average percentage of loss of weight	8.1 per cent
Average percentage normal gain should have been	52 per cent
Average dose of radium given	7,474 milligram-hours
Average duration of life	17 days
Shortest duration of life	11 days
Average dosage per kilo	15,570 milligram-hours
Average dosage round cage	7,663 milligram-hours
Average dosage square cage	7,200 milligram-hours
Round-cage animals received dosage equal to (at one inch distance)	213 milligram-hours
Square-cage animals received dosage equal to	113 milligram hours
Average weight for 213 mg.-hr. to dispatch	555 grams
Average weight for 113 mg.-hr. to dispatch	296 grams
Average age for 213 mg.-hr. to dispatch	39 days
Average age for 113 mg.-hr. to dispatch	19 days
Smallest single dose to dispatch	4,800 milligram-hours
Largest single dose to dispatch	8,600 milligram-hours
Single dose to dispatch in fourteen days	7,200 milligram-hours
Divided dose, six days apart, to dispatch in fourteen days	7,900 milligram-hours
11,217 mg.-hr. in three doses during eight days, required to dispatch	44 days
Adult rabbit given 9,000 mg.-hr. survived.	
Same rabbit given 11,590 mg.-hr. lived from initial dose	165 days
Same rabbit given 11,590 mg.-hr. lived from second dose	105 days

[1]Read before the Radiological Society of North America at the Fifteenth Annual Meeting, at Toronto, Dec. 2-6, 1929.

TABLE II

ANIMALS RECEIVING SUB-LETHAL DOSE OF RADIUM

CLINICAL OBSERVATIONS

Number of animals	eleven
Average age at beginning	24 days
Average beginning weight	290 grams
Average weight at death	537 grams
What would have been average normal weight at time of death, considering normal life expectancy	790 grams
Average percentage of gain in weight	85 per cent
Average percentage normal gain should have been	172 per cent
Average dose of radium given	5,100 milligram-hours
Average duration of observation	36 days
Average dosage per kilo	17,544 milligram-hours
Average dosage per round cage	none
Average dosage per square cage	5,100 milligram-hours
Round-cage animals received dosage equal to (at one inch distance)	none
Square-cage animals received dosage equal to (at one inch distance)	80 milligram-hours
Average weight for 80 mg.-hr	290 grams
Average age for 80 mg.-hr	24 days

TABLE III

ANIMALS RECEIVING LETHAL DOSE OF RADIUM

WHITE BLOOD COUNTS

12-18-27	12-21-27	12-22-27	12-24-27	12-26-27	12-27-27	12-28-27
No. 30 10,000	3,000	1,500	1,500	500	Dead	
No. 31 8,000	4,000	2,500	1,500	4,000	1,000	Dead
No. 32 9,000	4,000	1,500	1,000	1,000	2,000	1,000
No. 33 10,000	5,000	2,500	500	500	Dead	
No. 34 11,000	6,000	3,000	3,500	1,500	1,000	Dead
C. U.						
No. 16 14,000	4,000		900	500	Dead	

so long as the total amount was delivered within one week. If a month intervened between doses, a considerably higher number of milligram-hours was required to cause death. The reason for this phenomenon is not clear.

Observations upon the general appearance of the animals yielded rather meager information. Little change was noted except a reduction in activity to varying degrees, and anorexia. Occasionally diarrhea was observed. Death apparently came suddenly after a period of extreme quiet. Loss of weight was regularly present or there was a gain in weight far below that of the normal for the given rabbit. The white blood count was regularly reduced and to an extreme degree in the animals that died: but little change was noted in the red blood count or hemoglobin. Death apparently was always uneventful. Unfortunately, none of the animals was observed as it died—one was still warm when found. It is regrettable that the value of the autopsy in several of the animals was reduced, due to the post-mortem changes.

DISCUSSION

In every instance death was accompanied by certain phenomena.

Loss of weight, either actual or relative, was present in animals given the lethal dose of radium. The average loss of weight amounted to 8 per cent, whereas the normal gain in weight, during the period of observation, should have been 52 per cent. In animals given a sub-lethal dose, there was a gain of 85 per cent during the period of observation, whereas it normally should have

TABLE IV

AVERAGE WHITE BLOOD COUNT—FIVE RABBITS

12-18-27	12-21-27	12-22-27	12-24-27	12-26-27	12-27-27	12-28-27
9,600	4,400	2,200	1,600	1,400	1,300	1,000

TABLE V

ANIMALS RECEIVING LETHAL DOSE OF RADIUM

BLOOD COUNT SUMMARY

Number of animals	6
Average white blood count before radium	10,300
Average lowest white blood count after radium	750
Average time white blood count after radium	8.5 days
Average red blood count before radium	7,500,000
Average lowest red blood count after radium	5,800,000
Average time red blood count after radium	12 days

TABLE VI

ANIMALS RECEIVING SUB-LETHAL DOSE

BLOOD COUNT SUMMARY

Number of animals	9
Average white blood count before radium	5,500
Average lowest white blood count after radium	3,820
Average time of lowest white blood count	15.6 days
Lowest white blood count with which animal survived	2,200
Average red blood count before radium	4,900,000
Average lowest red blood count after radium	4,600,000
Average time of lowest red blood count	12 days
Average white blood count 48 hours after radium	10,100

been 172 per cent. The loss of weight, either actual or relative, was less in the animals given the sub-lethal dose, in each instance and in the average.

The *white blood count* was reduced in all animals observed, but to a greater extent in the case of the lethal dose than in the sub-lethal doses. Temporary leukocytosis occurred in all observed instances. Unfortunately blood counts were not made in many instances: the lowest white blood count recorded was 500 (death ensued within twenty-four hours); the lowest count observed in which the animal survived was 2,200.

All animals receiving an appreciable dose became *apathetic* in proportion to the dosage. Animals receiving the lethal dose practically all remained perfectly quiet for from twenty-four to thirty-six hours before death.

Anorexia seemed also to be a reliable indicator of reaction on the part of the animal. Failure to eat for a couple of days presaged death in most instances.

In some animals the shedding of fur was unquestionably greater than normal. Patchy *epilation*, however, did not occur.

There was marked *diarrhea* in one instance.

Thus, the four clinical findings, *loss of weight, leukopenia, apathy,* and *anorexia,* were constantly present and in direct proportion to the dosage.

Certain factors were of marked significance in determining whether the dosage would be lethal or sub-lethal, foremost among which was the age of the animal—the younger the animal the smaller the lethal dosage. The lethal dose was approximately twice as much in animals averaging thirty-nine days of age as it was in animals averaging nineteen days. In spite of the fact that the dosage per kilo was greater in sub-lethal doses than in lethal doses, the age of the animal seemed to be of the greater sig-

TABLE VII

COMMON MICROSCOPIC CHANGES

	Lethal	Sub-lethal
Bone Marrow	White blood count decreased Embryonic red blood count markedly increased. Dilatation, blood channels.	White blood count moderately decreased. Embryonic red blood count increased.
Kidney	Cloudy swelling of the convoluted tubules.	Moderately cloudy swelling.
Spleen	Lymphocytes few. Endothelial and reticular cells markedly increased.	Vascular distention. Endothelial hyperplasia.
Liver	Granular cytolysis. Cell membrane indefinite.	Granular degeneration of cytoplasm.
Heart	No common marked changes.	Normal.
Adrenal glands	No common marked changes. Normal to marked granular degeneration.	No common changes. Normal to slight reduction in stain.
Lung	Moderate hyperemia.	Normal.
Thyroid	No common marked changes.	Normal.
Thymus	Distention of vessels. Fifty per cent of parenchyma composed of lymphocytes and endothelial cells of blood vessels and lymphatics.	
Intestines		Fine granular degeneration of the lining epithelial cells.
Pancreas		No changes
Testicles	Granular degeneration of seminiferous tubules. No mitosis or spermatozoa.	

nificance. Of course, the weight was greater in the older animals. Lethal dosage, then, seemed to be in direct proportion to age. Any definite relationship between dosage and body weight *per se* could not be established.

A second factor associated with the lethal or sub-lethal character of the dose was the *time required for the lethal dose to act*. The shortest period between exposure and death was eleven days. The average elapsed time between treatment and death was seventeen days. These results seem to correspond to the period of maximum destruction of tissues as observed in daily clinical work, *viz.*, fourteen to eighteen days. When animals lived twenty days they usually survived. There were two exceptions: one had received multiple doses and the other was fifty-seven days old when exposed to radium. These two young animals and a single adult rabbit averaged eighty-three days' survival. Death in these instances was probably due to the secondary effects of the radium, *viz.*, serious changes brought about in vital structures or organs. At any rate, this is a problem for further study.

A third factor seriously affecting the character of the dosage delivered was the *duration of the exposure*. Briefly, dosage delivered within six days acts approximately the same as a similar dose delivered within two or three days. When the duration of the exposure is extended beyond seven days, in divided doses, the animal survives. In short, the longer the duration of the exposure beyond seven days the greater the dose tolerated. The increasing age of the ani-

mal may be a factor of greater importance than any possible acquired resistance. The problem of the latent period came to light in this investigation, but only as corroborative evidence. Inference might be drawn from the data gathered as to the latent period: that dosage delivered within seven days gives the same results as if delivered in a much shorter period, while dosage delivered over a longer period has to be increased to be lethal. Clinical experience seems to place the latent period at about six days. Here again is a problem for further study.

DISCUSSION OF MICROSCOPIC CHANGES

Of greatest significance are those changes found in the *bone marrow* and *spleen.* From the examination of these, it is seen that the white blood cells are markedly decreased. This finding is borne out by the white blood counts made upon a few of the animals. But little change was noted in the red blood cells so far as the count was concerned, but in the bone marrow embryonic red blood cells were increased. From this finding one may infer that the red blood content was not greatly affected but that there seemed to be some increased drain upon the red blood-forming organs. In an acute reaction it is unlikely that sufficient time elapsed to greatly influence the red blood mechanism. In the spleen it was noted that there was marked proliferation of the endothelial cells. Distention of the blood vessels and channels within these two blood-forming organs indicates profound changes in the circulation or in the circulating mechanism.

In the *kidney* and *liver* were found definite significant changes. There was cloudy swelling of the convoluted tubules, apparently in proportion to the dosage. In the liver granular cytolysis and destruction of cell membrane were evident also in proportion to dosage. The changes in these two organs would seem to indicate that there was some toxic substance eliminated through these organs.

The next change of importance was the destruction of almost the entire parenchyma of the *thymus gland,* leaving practically only endothelial cells and lymphocytes.

The *testicles* exhibited marked degeneration of the seminiferous tubules; there were no mitoses and no spermatozoa.

The heart, lungs, thyroid, adrenal glands, intestines, and pancreas showed no characteristic changes.

The *cause of death,* unfortunately, cannot be definitely stated. It is intimately and proportionately related to the white blood count, to the changes in blood-forming organs, namely, the bone marrow and spleen, and also closely related to the cells of the convoluted tubules of the kidney and the parenchymal cells of the liver, the latter two being excretory in function.

One other finding of great significance was the loss of weight. This finding varied directly in proportion to the dosage and was a reliable indicator of prognosis. The loss of weight might be attributed to the profound changes in the thymus gland or it may have been related to the changes in the blood-forming organs on the one hand or to the changes in the excretory organs on the other. (Unfortunately and inexplainably, there are no microscopic sections of the thymus gland in rabbits receiving sub-lethal doses. These organs were always removed at autopsy, but when the sections came through, the thymus was always absent.)

DISCUSSION OF THE GENERAL RESULTS

While the primary object of the experiments was not conclusively attained, yet some very significant information was brought to light. While the cause of death cannot be positively stated, yet it is so closely associated with the destruction of the white blood cells and with the loss of

weight that these two phenomena can be used as reliable indicators of impending death or probable recovery. The changes in the kidneys and liver may possibly be of great significance also, but it would seem more likely that these changes are secondary to the alterations in the white blood count, a viewpoint which is substantiated by clinical experience. White blood cells are extremely susceptible to radium rays, as evidenced by the leukopenia following heavy irradiation and by the rapid extensive destruction of the white blood cells in myelogenous leukemia. One contra-indication to heavy radium treatment clinically is a white blood count below 5,000. Counts below 3,500 are extremely dangerous. Further evidence that the changes in the kidneys and liver are not of the greatest significance is found in the fact that the microscopic changes in these organs were quite as marked in those animals receiving the sublethal dose and yet the animals survived, whereas in all those animals receiving the lethal dose, the white blood count went below 2,000. The only other factor which was a reliable indicator of prognosis was the loss of weight. If this factor could be definitely traced to the reduction of white blood cells or to the toxemia which so seriously affected the kidneys and liver or to the influence of the annihilated thymus gland, then one might conclude that the one or the other of these changes was the more important.

SUMMARY

1. Death due to external radium radiation is associated with *loss of body weight, extreme leukopenia, anorexia,* and *apathy.*

2. Death due to external radium radiation is associated with *marked degenerative changes in the bone marrow and spleen, cloudy swelling in the convoluted tubules of the kidney, granular cytolysis in the liver,* and *annihilation of the parenchyma of the thymus gland.*

3. *Lethal dosage* varied markedly with the *age of the animal,* the younger the animal the lower the dosage required. *Death occurred* within eighteen days, averaging seventeen days after exposure; and *dosage delivered within seven days acted as a unit* —dosage delivered in eight or more days required an increase to be lethal.

The experimental work discussed in this paper was begun in the laboratory of Professor Arthur L. Tatum, of the Department of Pharmacology, at the University of Chicago. Much credit is due him for the initiation of the methods employed and for valuable assistance during a considerable period of time and for suggestions upon its completion. The work was continued in the laboratory of Professor Lester R. Dragstedt, then Professor of Pharmacology at Northwestern University Medical School. For a short time, work was carried on in the Department of Physiology under the direction of Professor A. C. Ivy, of Northwestern University Medical School. The final work was done in the Department of Surgical Research at Northwestern University Medical School, under the direction of Professor Loyal Davis of the same college. The pathological findings were reviewed by Dr. H. R. Fishback, of the Department of Pathology. Acknowledgment with thanks is hereby given for the valuable assistance and many courtesies of these men.

DISCUSSION

DR. FRANCIS CARTER WOOD (New York): These interesting experiments on animals confirm in many ways the observations of the numerous earlier workers on the subject. The fall of the leukocytes was observed years ago after the first use of X-ray and radium. It is unfortunate that it is impossible to prove that the kidney and adrenal lesions observed are definitely due to a poison in the circulation. The early workers talked of a leukotoxine which was produced by the radiation, but that view has been abandoned and the clinical results obtained on cases of leukemia in human beings in which radiation has produced a rapid return to perfect health, makes it difficult to understand how a toxine could be produced by tissue destruction. In myelo-

genous leukemia a spleen weighing several kilos can be reduced to normal size in the course of a week or two, without the patient showing any evidence of a toxemia. The main value of these experiments is that general exposure of the body of either an animal or human being may cause prompt death. The loss of weight noticed in the rabbits is probably not important. Death occurred in human beings in the early days of radiation therapy more frequently from X-ray than from radium, for the radium, being approximately a point source, the intensity falls off rapidly owing to the conditions imposed by the inverse square law. X-ray, especially high voltage X-ray, is much more dangerous, and a number of patients have been killed by the exposure through a large portal with such radiation. The ordinary lead rubber is quite insufficient as a protection, and these unfortunate results have become much less frequent since the adoption of the large lead chambers to house the tube. No radiation then reaches the patient except through the portal. Nevertheless, even under these conditions, X-rays produced at 200 K.V. are scattered laterally throughout the patient's body to such an extent that it is possible by such scattered rays to see the bones of the hand in the fluoroscope at a distance of six or eight feet from the patient. That severe damage to the bone marrow may occur in susceptible subjects is obvious, and a number of deaths have occurred from radiation even under these conditions. The chief value of this paper, then, lies in rehearsing this important fundamental fact.

In experiments of my own on rats and mice, using X-ray, a marked variability in the animals as regards the time of death has been observed though they were all of the same strain, age, and weight. This suggests that there may be a great difference in the sensitivity of the bone marrow in different animals, a fact which we already knew from human pathology.

If the dosage is given slowly, a considerable number of animals die of pneumonia after the leukocytes have been reduced below a certain point. Others seem to die, as Dr. Larkin's rabbits did, from the anemia coupled with the organ-degenerations described.

Dr. Larkin (closing): I wish to thank the doctors for their comments. There were no instances of pneumonia in the animals treated with either lethal or sub-lethal dosage. This bit of work was done principally for personal reasons. The British early work did a great deal to clarify the actions of radium rays. There are many other works along this line, but this work was entered into for personal reasons. The facts are given to you just as they came. They seemed to be of practical significance in the treatment of patients day by day. The essayist is not a research man, but just makes his living by the practice of medicine.

EDITORIAL

M. J. Hubeny, M.D. *Editor*
Benjamin H. Orndoff, M.D. . *Associate Editor*

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NEW EXPERIMENTS ON CANCER CURE

It is an unfortunate thing that persons afflicted with cancer have had their hopes raised by over-enthusiastic newspaper reports of the San Francisco Coffey-Humber experiments, and are making great sacrifices, mortgaging their homes in some cases, to go there in the hope of being cured. Even the proponents of the experimentation do not claim any unusual treatment method or results to date. They are referring many of the early curable cases to management by radiation and surgery, refusing to use the Coffey-Humber injection on any but hopeless cases.

One reason why the physician should not grow enthusiastic over an alleged cancer cure is that he knows proof must be supplied of certainty that the patient had cancer, that it was made to disappear in all stages, and that it remained away permanently. A conclusive judgment regarding cure, therefore, before the passage of several years, would be illogical. In the presence of preliminary favorable results, the press and public do not understand this logic.

We understand that pharmaceutical firms are being bombarded with requests for the Coffey-Humber adrenal cortex extract. One firm is now making an adreno-cortin hormone for sale without claims. In the light of the fact that there are no publications on the preliminary experimental work of these men, such requests are highly premature. Neither are there any explanations of the character, dosage, or standardization of their extract. In a public statement to the Medical Society in Los Angeles on Feb. 17, 1930, Dr. Humber said that their extract was made by a "special process" from a part of the suprarenal cortex of sheep. He also said, "We have done no animal experiments —a thing we should have done, I admit."

On March 13, 1930, the Senate Sub-committee of the Committee on Commerce met in Washington, under a resolution directing Federal Government aid in discovering, investigating, and financing any successful or possibly practical cures for cancer. Many experts were called in to aid this Committee, and Dr. Coffey and Dr. Humber, of California, were also present. Dr. Coffey began by making a statement (in ten paragraphs) of his idea of governmental assistance in medical research, ending with: "Tenth, During the experimental stage and during completion thereof, any discovery shall continue the sole property of the discoverer. This shall be his reward."

Under questioning by Senator Johnson, he repeated his theory that the adrenal hormone was a stabilizer that would control tissue growth, causing a destructive effect upon malignant tissue, producing a peculiar type of necrosis "heretofore unknown," and without destruction of normal tissue.

Dr. Coffey continued (Report of Committee, page 6, line 10): "We discovered this active principle through a process created by ourselves. When we injected the extract in small doses of from 1 drop up to 15 or 16 drops, in the course of our experimental work, we found that most cases were using opiates for relief, and immediately thereafter were relieved of pain and after two or three injections, the pain entirely

disappeared, and in from 24 to 48 hours the cancer began to slough. That has already taken place in over 1,300 cases that we have injected and all those cases were inoperable. We use our extract in different types of cancer and likewise in sarcoma."

After recess the questioning was resumed.

Senator Johnson: "There is no claim on your part that you have found a cure for cancer?"

Dr. Coffey: "No, sir. I want it distinctly understood that we do not claim a treatment or cure for cancer [page 11, line 18]. Patients came by hundreds and likewise to our department in Los Angeles, until they reached 1,300 injections a day. Now it is impossible for us in an experimental way to conduct this thing in an orderly manner, and something must be done by the public press. I call attention to these poor unfortunate people who are grasping at straws—flocking to California in the hope that this is a cure. We feel that it is wrong on our part even for a second to encourage them. We are offering this as a theory. We believe it is a success, but it is for the scientific gentlemen to demonstrate its use and it will require a large expenditure of money, granting our theory is correct."

Then Senator Jones took up the questioning: "Now isn't this the result, that you get only persons in rather extreme stage?"

Dr. Coffey: "Absolutely. If we see a case can be operated upon, we refuse to give injection. If we, from our years of experience, see that radium will do that man any good, we refuse."

Senator Jones: "Have you ever treated any of the earlier stages of the trouble?"

Dr. Coffey: "We refuse to treat any of the earlier stages as an experiment. We have no right to do that scientifically. We must prove our position before we have the right to offer this as a cure or treatment. We follow usage and the scientific use of the knife, X-ray, and radium."

Following Dr. Coffey, others were questioned on the general idea of governmental aid for all research in cure of disease. Dr. Joseph C. Bloodgood, Dr. C. C. Little, and Dr. James Ewing emphasized the need of the passage of years before a conclusion regarding any cancer treatment could be reached. Dr. Ewing advised the Government to put less stress on the elusive cause of cancer and more time and financial aid on radiation facilities for treating the cancer cases already in the country.

In conclusion, regarding the Coffey-Humber Hospital release, we feel that the broadcast of early undue publicity has lessened confidence in all cancer treatment. There are a score of good men, including the leading cancer specialists, who have investigated and who express nothing but profound disappointment with both the clinical and pathological results of the Coffey-Humber injections. Postmortem examinations, which have been made in at least thirty cases, do not reveal any definite specific destruction of cancer tissue or evidence that the spread of cancer in the bodies of the afflicted patients has been retarded. There has evidently been too much Sunday supplement emphasis, or perhaps the combination of a chief surgeon and a superintendent of a railroad hospital may have made the press contacts too hard to control.

ALDEN WILLIAMS, M.D.

THE PROGRESS OF SURVEY OF RADIOLOGY

By the American Medical Association

The questionnaire which was prepared by leaders in radiology was sent out to a mailing list of 1,654 persons representing that specialty. A total of 1,150 questionnaires have been filled out and returned.

The Council on Medical Education and Hospitals, which was asked to do this work.

is now tabulating the returns, after which it will publish its report, and will also prepare a tentative list of directors of approved radiological laboratories. The "Essentials," which have been prepared by representative leaders in the field, have accompanied each questionnaire sent out.

All who have not sent in the questionnaire should do so. Additional blanks will be furnished by the Council on Medical Education and Hospitals of the American Medical Association, 535 North Dearborn Street, Chicago.

COMMUNICATION

To the Editor of RADIOLOGY:

Dear Doctor:—In reading over the various American and foreign journals in the field of radiology, I notice that a variety of symbols are used to express the recently adopted unit of X-ray intensity; this in spite of the fact that the terminology is clearly defined in the report of the Second International Congress of Radiology.

For example, most writers speak of applying so many "r-units." In ordinary physical practice, the unit of resistance is the ohm and its symbol is r or $\sim$. When speaking of the resistance of a coil of wire it is correct to say so many "ohms," but never so many "$\sim$-units" or so many "ohm units." Likewise we speak of so many "volts" but never so many "v-units" or "volt units." In writing the above terms it is correct to use "52$\sim$" or "38 V" but never "52$\sim$-units" or "38 V-units."

Thus, to be in keeping with physical practice and the international definitions we should speak of so many "roentgens" and write, for example, "100 r" and not "100 r-units" or "roentgen units."

In future publications from the Bureau of Standards the correct nomenclature will be observed and I feel that this should be brought to the attention of radiologists so that in the future we may have a uniform terminology in the literature.

Another question of terminology was also brought to my attention through the Bureau's editorial board. "Constant potential," as the term is usually used, rarely refers to true constant potential since all commercial X-ray equipment coming under such a head is quite far removed therefrom. (So far as I am aware, Prof. Duane has the only true constant potential X-ray generator, his being a storage battery.)

A national committee on electrical definitions has tentatively adopted the term "ripple potential" to describe such voltages as are produced by the ordinary kenotron-condenser rectifiers. The terms "ripplage" and "ripplance" will be used to express the amount of variation from true constant potential. The complete definitions of these terms will be given in a paper which is now in the press.

Respectfully,

LAURISTON S. TAYLOR.

Washington, D. C.
May 1, 1930

THIRTY-FIFTH ANNIVERSARY OF DISCOVERY OF THE ROENTGEN RAY

The Chicago Roentgen Society commemorated the thirty-fifth anniversary of the discovery of the X-rays by William Conrad Roentgen, at a dinner meeting held at the Lake Shore Athletic Club, May 8, 1930, at which about ninety were present.

The speakers of the evening were: I. Seth Hirsch, M.D., New York City, "Eulogy on Roentgen"; I. S. Trostler, M.D., Chicago, "Original Communication of the Discovery of X-rays by Roentgen"; Will

Pusey, M.D., Chicago, "The Pioneer Development of Radiation Therapy"; Paul B. Batty, Chicago, "The Electrical Engineer and the Physicist: Pioneer Work in Electrical and Mechanical Development of X-ray Apparatus." Charles B. Reed, M.D., Chicago, President of the Chicago Medical Society, acted as toastmaster and spoke on "The Relation of Radiology to General Medicine." The Chicago Roentgen Society was favored with a letter of congratulation from President Hoover and a telegram from Louis L. Emmerson, Governor of Illinois, copies of which follow.

[LETTER]

April 25, 1930.

Chicago Roentgen Society
Chicago, Illinois

My Dear Friends:

I cordially commend the celebration of the discovery of the roentgen ray, for it is one of the beacon lights of that steady progress by which science is enlightening the darkness of the unknown and guiding mankind ever forward into new knowledge and mastery of Nature.

Yours faithfully,
[Signed] HERBERT HOOVER.

[TELEGRAM]

April 29, 1930.

Chicago Roentgen Society

In extending to you my greetings on the celebration of the thirty-fifth anniversary of Roentgen's discovery of the roentgen ray I congratulate you on your vigorous efforts toward vitalizing the memory of this great scientist, who has bequeathed to mankind everlasting benefactions of immeasurable magnitude. His discovery of the X-ray has made available a means of therapy and an aid to diagnosis that no reputable doctor or dentist is willing—or even permitted—to ignore or neglect. That courts of justice freely grant to plaintiffs large sums in damage when evidence indicates professional neglect of X-ray usage, which apparently has resulted in extended physical suffering or deformity, suggests the indispensable character that X-ray equipment has assumed in the field of medical practice.

LOUIS L. EMMERSON, *Governor.*

SECTION ON RADIOLOGY, AMERICAN MEDICAL ASSOCIATION

The officers for the Section on Radiology, American Medical Association, for the coming year are as follows: *Chairman,* Arthur W. Erskine, M.D., Cedar Rapids, Iowa; *Vice-chairman,* Ralph S. Bromer, M.D., Philadelphia, Pa.; *Secretary,* G. W. Grier, M.D., Pittsburgh, Pa.; *Executive Committee,* M. J. Hubeny, M.D., Chicago, Ill., F.M. Hodges, M.D., Richmond, Va., and Arthur W. Erskine, M.D., Cedar Rapids, Iowa. The *Section delegate* is James T. Case, M.D., Chicago, Ill., and the *alternate Section delegate* is W. W. Wasson, M.D., Denver, Colorado.

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ARTHRITIS

A Clinical Study of Chronic Arthritis. Emil G. Vrtiak and Edwin P. Jordan. Jour. Am. Med. Assn., March 22, 1930, XCIV, 863.

Many others have concentrated on only one or two phases of this problem, *e.g.*, basal metabolism, sugar tolerance, and relation to focal infection. The authors have examined from as many angles as possible the clinical records of a group of patients with chronic arthritis. They have used Goldthwaite's classification, dividing their patients into three groups: hypertrophic arthritis (ostearthritis), atrophic arthritis (rheumatoid arthritis or arthritis deformans), and infectious arthritis. The latter is not clinically characteristic, and, radiologically, shows no bony changes.

No definite relationship between the menopause and chronic arthritis was apparent. A history of rheumatic disease in the family and the history of typhoid occurred often enough to warrant more detailed investigation. Secondary anemia was frequent in infectious arthritis, while an erythrocytosis was common in the hypertrophic form. Leukocytosis was a usual occurrence in infectious arthritis, but leukocytosis and leukopenia occurred with about equal frequency in the hypertrophic type. A questionable tendency towards a plus metabolic rate was found in the infectious, and towards a minus rate in the hypertrophic type of arthritis. A percentage of positive Wassermann tests, slightly higher than that usually found in similar age groups of non-arthritic persons, was found.

Foci of infection were found in a high percentage of patients with infectious or hypertrophic arthritis. In many, treatment of these foci resulted in marked improvement, while some patients became much better in the face of unremoved foci of infection.

C. G. SUTHERLAND, M.D.

BONE DISEASES (DIAGNOSIS)

A Critical Survey of Charcot's Arthropathy: Analysis of Eighty-eight Cases. Udo

J. Wile and Milton G. Butler. Jour. Am. Med. Assn., April 5, 1930, XCIV, 1053.

In their study the authors tabulate their observations to show a definite relation to the following eleven factors: age of onset, sex, joint involved, history of pre-existing syphilis, duration of syphilis previous to the onset of the joint involvement, means of establishing the diagnosis, incidence of trauma, associated spinal fluid reactions, type of cerebrospinal disease present, roentgen observations, and, finally, additional associated data.

A comprehensive survey of all these factors in a series of about eighty-eight cases thoroughly reviews the subject.

C. G. SUTHERLAND, M.D.

Articular Chondromatosis. Ettore Conte. La Radiologia Medica, March, 1930, XVII, 237.

The author states the difficulties confronting the diagnosis of this disease. With the aid of the radiological and clinical data supplied by his personal experience, and that offered by the medical literature, he gives a complete sketch of this morbose process. He establishes its differential characters from both the etiological and clinico-radiological viewpoints, especially in comparison with arthritis deformans, which seems to be the affection more frequently confused with articular chondromatosis.

L. MARINELLI.

BONE TUMORS (DIAGNOSIS)

Ewing's Sarcoma: Small Round-cell Sarcoma of Bone. Murray M. Copeland and Charles F. Geschickter. Arch. Surg., February, 1930, XX, 246.

There is a foreword on this article, written by Dr. Joseph C. Bloodgood, in which he gives the benefit of his experience in bone tumors in general, and this tumor in particular. The authors have reviewed all of the bone tumors of the Johns Hopkins Hospital, representing something over 1,500 cases.

Ewing's sarcoma was found to be essentially a disease of early life, 95 per cent of the cases in this series occurring in persons between the ages of four and a half and twenty-five. Among the 400 sarcomas in this series, 15 per cent were found to be Ewing's sarcoma. Pain was an outstanding symptom in 83 per cent of the cases, and was noted as the first symptom in 35 per cent. It varied from a tenderness or soreness to continuous pain, either dull aching or sharp shooting pain. In 90 per cent of the cases a mass could be palpated, and in 19 per cent a swelling was complained of as the initial symptom. On palpation the majority of the tumors presented an indurated swelling, with a surface ranging from rough and irregular to smooth, and totally immobile, apparently continuous with the bone. The bones involved in the greatest number of cases have been the tibia, femur, fibula, humerus, pelvis, and scapula, and in smaller numbers in many other bones. Pathologic fracture was of relatively rare occurrence in this series.

Fever was noted in a number of these cases. The blood examination revealed no findings significant in this condition. Many of the patients showed very little change in nutrition until the terminal stages of the disease. Internal metastases usually presented themselves clinically late in the disease.

The roentgen-ray studies revealed that the earliest stages of the lesion presented the most difficulty in diagnosis. In the early cases, there was a slight expansion of the shaft, with a periosteal reaction looking somewhat like onion peel. The cortex of the shaft appeared thickened, with some mottling in the region of the medullary cavity, due to areas of increased density. Later in the disease, there was considerable extension of the tumor along the shaft. The medullary cavity often showed osteoporosis, and the cortex showed evidence of destruction. There were varying degrees of periosteal reaction, and a characteristically increased density of the bone in the region of the widened cortex. Osteophytes arranged irregularly or at right-angles to the cortex occasionally appeared in the picture. In a number of the early cases, the first evidence of tumor formation was given by an increase in density of bone.

The gross examination of the tumor showed that, with one exception, its bulk lay subperiosteally. The medullary cavity sometimes contained a small portion of the tumor, but, usually, this region was constricted or totally occluded by new reactive bone. When the involvement of the bone was diffuse, subperiosteal formation of new bone was both parallel and at right-angles to the cortex. Due to the growth of the tumor and subsequent hemorrhage, there was a gradual separation of the periosteum from the underlying cortex. The parallel deposits of new bone appeared to be the result of proliferation of the peripheral layer of the cortex when the periosteum had suffered minute separation from the bone. This gave the onion-peel-like formation characteristic in roentgenograms of the early stages. With increased separation of the periosteum, spicules of new bone from the subperiosteal region are laid down at right-angles to the shaft rather than parallel. This is due to the blood vessels perforating Volkmann's canals which determine the direction of the new growth of bone when they are pulled outward in maintaining their continuity after the periosteum has been elevated. The two types of formation of bone, parallel and radiating, duplicate the process observed in the embryo. The microscopic examination revealed a more or less constant cellular picture. There was a small polyhedral cell with a round or oval nucleus. The cytoplasm was scanty and did not stain well. The nucleus was deeply stained, showing a definite limiting membrane. Nucleoli were rarely seen, but mitotic figures were not infrequently noted. There appeared to be no intercellular stroma, but the tissue was divided into lobules by a fibrous trabeculation. Various other microscopic changes were found which will not be gone into in this abstract.

The most frequent sites of metastases were the lungs, lymph glands, and the skull. The spine, scapula, and clavicle, however, were also frequently the sites of metastases.

In differential diagnosis, many other conditions must be considered, especially inflammatory disease of bone. In ten cases the diagnosis of pyogenic periostitis or osteomyelitis was made; in nine cases, tuberculosis of bone; in six cases, syphilitic periostitis or osteomyelitis, and in one case, typhoid osteomyelitis. Clinically, multiple myeloma was noted as the source of confusion in two of the cases of Ewing's sarcoma. Osteogenic sarcoma must also be differentiated from this condition, as well as metastatic carcinoma.

In the treatment of this condition, the authors believe that in cases in which metastases have not occurred, amputation for lesions in the lower extremity below the upper third of the femur, and resection of bone for lesions in the upper extremity, followed by post-operative irradiation, offer more hope of cure than does irradiation alone. If the lesion occurs in the upper portion of the femur or has become extensive, irradiation should be resorted to and continued in therapeutic doses until amputation becomes a necessity to relieve pain.

Out of 52 cases of Ewing's sarcoma, eight are living and are apparently well. All of these patients are over five years, and the average duration of life is seven years and eight months for the eight cases. In one group of 13 cases which had amputation with irradiation, there was a post-operative duration of life averaging 29.2 months. In three cases in this group, the patients were found to be well, with an average duration of life of five years and seven months. In another group which had amputation without irradiation, there were 24 cases, with an average duration of life of twenty months. In four cases in this group, the patients are well, with an average duration of life of six years. In the third group, which had irradiation alone, there are eight cases, with an average duration of life of 27 months, and in one case in this group, the patient is living 53 months after treatment.

Coley's toxins apparently have had no effect on the duration of life, whether given alone or with other forms of treatment.

Exploration does not ordinarily affect the prognosis in which radical operation or X-ray treatment follows exploration. In two cases, or 25 per cent, in which the patients are living over five years, exploration was done before resorting to operation.

HOWARD P. DOUB, M.D.

CANCER (DIAGNOSIS)

Primary Adenocarcinoma of the Jejunum, with a Report of Two Cases. Francis C. Newton and Richard C. Buckley. New Eng. Jour. Med., Feb. 6, 1930, CCII, 255.

Two examples of primary adenocarcinoma of the jejunum are reported. These were similar in location but produced different clinical symptoms. In the first patient, the chief symptom was a severe and unexplained secondary anemia. Ulcerated carcinoma of the jejunum was an unexpected finding at autopsy. In the second patient, high intestinal obstruction occurred and the diagnosis was made by X-ray examination. A tumor was resected and within a short time retroperitoneal metastases were found.

W. W. WATKINS, M.D.

The Relationship between the Clinical and Pathological Findings in Primary Pulmonary Malignancy. Ralston Paterson. Can. Med. Assn. Jour., March, 1930, XXII, 333.

Carcinoma of the lung is a rapidly progressive disease, the average duration being about six and one-half months. During this period the pathologic processes show a number of characteristic changes, and with these are associated characteristic radiologic and clinical findings.

Classified from the standpoint of foci of origin, lung malignancy is subdivided into bronchial and parenchymal. Bronchoscopy is the diagnostic agent of choice in the bronchial type.

Bronchial growths are not visualized early from the roentgenogram. When the shadow does show it will always be unilateral and of an infiltrating nature. If the growth is chiefly intraluminal and tends to obstruct the bronchus, the roentgenologic picture is characteristic, being an atelectasis of the part of the lung shut off.

The first symptom of the bronchial type of growth is cough, associated later with hemoptysis. Secondary infection is followed by bronchiectasis peripheral to the lesion, with sputum and fever.

Growths of the parenchymal type have their primary focus within the lung substance or from the wall of a minor bronchus. They are demonstrated easily on the X-ray film as irregular nodular masses in the lung fields. Later the growth involves a bronchus, and atelectasis is added to the picture. Later still the pleura is involved and pleural effusion is added. The symptoms of this latter type are, first, a deep-seated chest pain, with, later, cough and bleeding. With pleurisy and infection supervening, there is added fever and toxemia.

L. J. CARTER, M.D.

Notes on the Etiology of Cancer. Albert Soiland. Am. Jour. Surg., March, 1930, VIII, 654.

The author gives a very thorough dissertation on the influence of mechanical irritation on the production of cancer, and concludes that the importance of this has been greatly over-estimated. He considers that other factors must be present in addition to the irritation in order to produce cancer. The work of Dr. Maud Slye on the hereditary theory would appear to be an outstanding contribution to the work on the etiology of cancer.

The author brings up several other points to be considered: First, the types of cancer under discussion show a predilection for a junction point of two epithelial structures; second, the combined action of constant irritation and physiological function at this point brings on early senility of the cells in these parts so as to invite cancer development.

Finally, there seems to be a tendency to turn toward the endocrine system, which may after all be the sole custodian of the secret.

H. P. DOUB, M.D.

Primary Lung Tumor: Report of Six Cases with Necropsies. Lila M. Bonner. Jour. Am. Med. Assn., April 5, 1930, XCIV, 1044.

Primary cancer of the lung is the basis of this essay, and a report of six cases with

necropsies is made. The literature is reviewed, with a discussion of the etiology and pathology of the disease. The duration of the disease in the cases presented was from four months to three years. One occurred with a lung abscess—lung abscess has been commonly found in conjunction with cancer of the lung.

The cardinal symptoms of early primary lung tumor are pain, dyspnea, cough, sputum, and fever. Persistent pain in a person of the cancer age should always call to mind the possibility of a hidden malignant condition.

Surgery offers the only hope of cure. Roentgen irradiation may give marked temporary palliation, but disappointing end-results.

C. G. SUTHERLAND, M.D.

CANCER (THERAPY)

Carcinoma of the Prostate. George Gilbert Smith. New Eng. Jour. Med., April 17, 1930, CCII, 756.

Cases of cancer of the prostate fall into three classes. In Class A, the growth is confined within the capsule of the prostate and total prostatectomy is the procedure of choice. In the author's series of 65 cases, 29 were in this class. In Class B, the growth has extended beyond the prostatic capsule, but does not show evidence of metastases; treatment should be by insertion of radium needles or seeds into the gland; 17 of the 65 patients were in this class. In Class C, metastases have developed. Palliative treatment is best given by high voltage X-ray; of the 65 cases, 19 were in this class.

W. W. WATKINS, M.D.

Carcinoma of the Uterus—Its Treatment by Radiation. Albert Soiland and William E. Costolow. Calif. and West. Med., February, 1930, XXXII, 95.

The authors use the grouping advised by Schmitz in the diagnosis of uterine carcinoma. Studying statistics, they note that surgical results on carcinoma of the cervix are extremely poor, even from the most radical operation. From the clinics of the best operators the five-year cures amount to less than 20 per cent.

Increasing attention has recently been given to the consideration of the type of cell in the particular growth, and to the question of radiosensitivity. For many years it has been noted that cervical carcinoma has varied in its response to radiation. Where the conditions clinically appeared similar, and were treated by the same technic, it has been observed that the response in one case would be slow and uncertain, while in other cases the disease would melt away rapidly and completely. It is now known that this is largely due to a difference in radiosensitivity of the cells. The practice is now to classify the carcinomas according to cell type.

Regarding the technic of the treatment, the author's procedure is to give 3,500 mg. el hrs., 60 per cent of which is placed against the cervix and filtered with two millimeters of gold and one millimeter of rubber. The other 40 per cent is placed within the uterus, filtered with one millimeter of gold and one millimeter of rubber. Three weeks later, 3,000 mg. el hrs. are given with the same type of applicator. No further radiation should be given in the next six to twelve months.

The patient is observed at monthly intervals, and late recurrences, appearing a year or so after the original therapy, are often treated with small doses of radium applied locally, although great care is exercised. Often suspiciously thickened areas remain for several months and finally disappear. These areas should not be treated unless they are of definite malignancy. Experience in observation is a most valuable asset at this stage of the treatment.

In the treatment of carcinoma of the fundus the authors use combined radium and roentgen-ray treatment. A total dosage of 4,000 to 5,000 mg. el hrs. of radium, filtered by one millimeter of gold and one millimeter of rubber, is applied intra-uterine. This is followed by deep roentgen-ray therapy in about two weeks.

Roentgen-ray therapy should be combined with radium in all cases of uterine carcinoma,

unless contra-indicated by the poor general condition of the patient. Advanced cases of carcinoma of the fundus uteri should be treated by radiation alone. It seems possible that results may be obtained by radiation in early cases of carcinoma of the fundus, which will equal the present surgical results. Carcinoma of the cervix uteri is no longer a surgical condition and should be treated by radiation alone.

F. B. SHELDON, M.D.

Rodent Ulcer. Richard L. Sutton, Jr. Jour. Missouri St. Med. Assn., March, 1930, XXVII, 103.

The term "rodent ulcer" is not scientifically used; it is frequently used either for basal-cell or prickle-cell carcinoma of the skin, although there is a marked clinical and histopathologic difference in these two growths. After a thorough discussion of the various types of lesions which are sometimes called "rodent ulcer," and also a discussion of the various methods of treatment, the author concludes that the term "rodent ulcer" should be discarded, and the correct term, based on histopathology, should be substituted. Treatment should consist in the extinction of the neoplastic cells in the manner which will give the best cosmetic results. Irradiation is the method of choice, and as between X-ray and radium, the latter is preferable, on account of the accuracy with which the dose may be applied.

W. W. WATKINS, M.D.

On Radiation Effect and Radiation Dosage Based on Observations in Uterine Carcinoma, with Pre-operative Irradiation. W. Lahm. Strahlentherapie, 1930, XXXVI, 237.

The examination of cervical carcinoma through the vaginal speculum does not give an accurate idea of the extension of the process. A number of illustrations showing the cervical os as seen through the speculum and in the sagittal section explain this point. It is difficult, if not impossible, therefore, to learn from the study of an excised cervix which had been previously irradiated, how much of the tumor was destroyed by the rays. Macroscopic and microscopic studies of a series of patients who had been treated by roentgen rays and radium demonstrated that only the tissue infiltrated by carcinoma was destroyed. No explanation can be given so far for this observation. It is possible that the limited destruction is due to a definite sensitivity of the diseased part, or it may also be possible that the necrotic carcinoma forms a cytolytic substance. A discussion of the problem of dosage pertaining to carcinoma of the cervix and metastasis in the parametrium follows, which is supplemented by a number of case histories.

ERNST A. POHLE, M.D., PH.D.

Malignancy of the Oral Cavity. C. M. Hamilton. Jour. Tennessee St. Med. Assn., March, 1930, XXIII, 79.

Cancer of the mouth is curable, but, to obtain the best results, it is necessary to start treatment early. Palliation and insufficient treatment are worse than none. Proper combination of methods offers the most success. Every case presents the double problem of the local lesion and the lymph drainage areas. The local lesion can be removed by excision, cauterization, electrocoagulation, or radiation. The dual procedure of electrocoagulation and radiation is more effective in destroying the local lesion than either method singly. Treatment of the lymph glands is more important than treatment of the local lesion. The result in unselected cases varies from 15 to 60 per cent with different authorities. Cancer of the tongue and floor of the mouth are the most unfavorable, while epitheliomas of the alveolar ridge and hard palate offer better prognoses.

W. W. WATKINS, M.D.

THE CHEST (DIAGNOSIS)

Interpretation of Roentgenograms of the Chest in Children Based on Observations at

Necropsy: III.—Diseases of the Lungs, of the Pleura, and of the Mediastinum. John A. Bigler. Am. Jour. Dis. Child., January, 1930, XXXIX, 91.

Correlation of 171 necropsy and roentgen-ray examinations of the lungs is attempted. Bronchopneumonia was more common and the pleural involvement was less common than in lobar pneumonia. Two cases of congenital laryngeal stridor gave no roentgen-ray findings other than the general picture of emphysema. Pleural adhesions were found more often by the pathologist than by the roentgenologist.

In pneumothorax and pyopneumothorax necropsies showed connection with a bronchus. The author states that these conditions occur frequently following pleural puncture, both diagnostic and therapeutic. The hilum shadows and linear markings are made up mostly by blood in the blood vessels and not by the bronchi. Normal lymph glands do not cause shadows. Hypoplastic lymph nodes, either caseated or inflammatory, cannot be recognized if they do not contain calcium. The size and shape of the hilum shadows are not influenced by active infection alone, but by previous infections.

A number of roentgenograms, illustrating lung and mediastinal pathologic change confirmed by necropsy, were included.

F. B. MANDEVILLE, M.D.

Massive Collapse of the Lung. H. H. Murphy. Can. Med. Assn. Jour., March, 1930, XXII, 327.

Massive collapse of the lung is a condition in which the lung, without the presence of any gross lesion, such as bronchial obstruction, pleural adhesion, etc., interfering with the free entry of air, becomes airless to a greater or lesser degree. It occurs most frequently after operative treatment for inguinal hernia or appendicitis. It may involve a lobule, a lobe, one entire lung, or even both lungs.

The important causes are a combination of three conditions, namely, a thick pleural exudate, viscid bronchial secretion, and some suppression of the cough reflex.

From the standpoint of symptomatology there are two types of cases, depending on the presence or absence of pneumonia signs.

The physical signs are: displacement of the heart to the affected side, and depression of the chest wall, with the usual signs of consolidation.

The atypical case may escape detection if a bedside radiographic examination is not made. The radiographic evidence is clear and unmistakable.

Two of the author's interesting cases are reported.

L. J. CARTER, M.D.

Infection of the Upper Respiratory Tract as an Etiological Factor in Pulmonary Disease. I. R. Smith. Can. Med. Assn. Jour., February, 1930, XXII, 194.

The object of this paper is to show the important rôle played by upper respiratory tract infections in the etiology of pulmonary disease. The removal of such gives excellent results.

Analysis is made of 1,510 cases where pulmonary complaints were the leading feature. The common symptoms were: cough, postnasal discharge, loss of weight, general weakness, rise of temperature on exercise, expectoration, dyspnea, and anemia. Of this whole group 166 proved to be tuberculous. The major portion of the remainder was diagnosed as cases of bronchitis, bronchiectasis, or asthma. These were divided into seven groups, according to the presence or absence of one or more of the following: clinical chest findings, X-ray chest findings, and upper respiratory findings, including sinuses, nose, and throat.

In three of the groups clinical chest findings were absent; in three, X-ray findings were absent, and in three, upper respiratory findings were absent.

The radiographic findings group themselves into three classes: (1) enlarged nodes in indefinitely enlarged hilum shadows, with thickening of the lower bronchial tree; (2) thick-

ening of the upper bronchial tree, and (3) a combination of (1) and (2).

The associated upper tract diseases found were: deviation of septum, hypertrophied turbinates, sinus disease, nasal mucous membrane ulceration, diseased tonsils, adenoids, pyorrhea, granular pharynx.

The author emphasizes the great importance of collaboration between the laryngologist, the internist, and the radiologist in the diagnosis.

L. J. CARTER, M.D.

The Roentgenological Aspects of Empyema. Ralston Paterson. Am. Jour. Surg., March, 1930, VIII, 638.

The author advises a very thorough fluoroscopic examination of the chest in all possible positions in order to accurately determine the exact position and extent of the lesion. This is then followed by films made in several positions which have previously been found, fluoroscopically, to show the fluid to the best advantage.

The roentgenologic appearances produced by free effusions in the pleural cavity are discussed, and these are compared with the appearances of true purulent effusions. With free fluid there may be a slight change in its distribution with changes of posture, but, with true pyogenic exudate, there is very little alteration in the fluid level with changes of posture, owing to the fact that both the parietal and visceral pleura are coated with thin layers of fibrinous exudate, which tend to fusion at the edges.

The fluid shadows must be differentiated from consolidation of the lungs, malignancy, and atelectasis. The greatest difficulty encountered, however, is a co-existence of fluid with pneumonia or malignancy.

Encapsulated effusion may form in relationship to any portion of the surface of the pleura, superficial or deep. This must be differentiated from lung abscess, plaques of dense pleural thickening arising as residues of old empyemata, and benign or relatively circumscribed malignant tumors of the pleura.

If, for any reason, an empyema becomes chronic, with multiple pockets, simple chest roentgenograms will frequently not tell the whole story. Injections of these sinuses and pockets with lipiodol or some other opaque medium is often of great value.

H. P. DOUB, M.D.

Acute Mediastinal Abscess. B. J. Malnekoff. Am. Jour. Dis. Child., March, 1930, XXXIX, 591.

Acute mediastinal abscess is rare in infancy and childhood. A case of an infant twenty-one months old is presented. Twelve days after the onset of upper respiratory symptoms a roentgenogram of the chest was negative. Three weeks after the onset of symptoms a roentgenogram showed a shadow of increased density in the right upper chest, apparently continuous with the mediastinum and presenting a fairly well rounded outer border. Fluoroscopy and films at another examination showed a dense shadow in the anterior mediastinum outside of the lung.

Measles and otitis media were complicating factors in this case. The von Pirquet test and blood cultures were negative.

Repeated aspirations in the third right intercostal space anteriorly, just adjacent to the sternum, were made, and 45 c.c. of thick grayish pus containing streptococci and pneumococci was obtained. Ultra-violet therapy was also used.

The author concludes that the mediastinal abscess was due to encapsulation of suppurating tracheobronchial lymph glands draining the upper respiratory tract.

F. B. MANDEVILLE, M.D.

The Roentgen Findings in Atypical Influenza Pneumonias. Georg Peschel. Röntgenpraxis, April 1, 1930, II, 315.

During the influenza epidemics of the last few years the author frequently observed atypical pneumonias, which presented considerable diagnostic difficulties. Extensive pneumonias were seen with very few and slight clinical symptoms. The chronic condi-

tion resulting can easily be confused with a cirrhotic tuberculosis, syphilis of the lung, or many forms of bronchial carcinoma. In other cases the differential diagnosis from an early tuberculosis could not be made roentgenologically. Miliary bronchopneumonias were seen occasionally, which simulated the appearance of miliary tuberculosis. When confronted with the picture of a so-called healed miliary tuberculosis, one should think of the possibility that it may be the resulting stage of miliary bronchopneumonia as seen in influenza.

H. W. Heike, M.D.

Pleurisy in Infants and Children: Radiologically Demonstrated. E. Gordon Stoloff. Am. Jour. Surg., March, 1930, VIII, 662.

The author discusses acute pleurisy together with effusion and gives the ordinary roentgenological findings as usually described.

He then describes empyema together with the various types of encapsulated fluid, depending upon their location and the structures with which they are in contact. He states that encapsulation of purulent fluid is common in the earlier years of life and may be situated in almost any portion of the chest, including the mediastinum. He combines fluoroscopy with films in various positions in the diagnosis of these conditions.

There is also a chapter on the topography of the fissures and lobes of the lungs, together with points in roentgen diagnosis.

This article is written in text-book form and is difficult to condense into a small space.

H. P. Doub, M.D.

Bronchiectasis. Alton Ochsner. Am. Jour. Med. Sci., March, 1930, CLXXIX, 388.

This is a fairly exhaustive study of the subject, with an excellent bibliography. The author states that bronchiectasis is one of the most frequent chronic pulmonary affections. Chronic bronchitis, influenza, and nasal sinusitis are the most frequent causative agents. Text-book descriptions represent late stages of the condition. The early diagnosis can be made only by X-ray, following intratracheal introduction of iodized oil for outlining the tracheobronchial tree. The repeated introduction of this oil is of distinct therapeutic value. The results of 1,500 bronchographies are reported. One hundred and twelve cases were treated, and of these 32 per cent were symptomatically cured.

W. W. Watkins, M.D.

CIRCULATORY DISTURBANCE

Volkmann's Ischemic Contracture. Henry W. Meyerding. Jour. Am. Med. Assn., Feb. 8, 1930, XCIV, 394.

The disastrous complication of injury which produces contracture of the flexor muscles of the fingers, wrist, and forearm, described by Volkmann in 1869, interests every practising physician. The descriptive term "ischemic contracture" is preferred by Meyerding. The condition is a deformity, usually of the forearm, wrist, and hand, with or without paralysis. It complicates trauma, usually fracture, and produces varying degrees of disability. Injury to muscle cells from interference with circulation, and degeneration of muscle as a result of toxins produced by venous stasis have been advanced as etiologic factors. Thomas held circulatory disturbance in itself as insufficient, emphasizing nerve involvement. Jepson's experimental studies demonstrated that a combination of factors is concerned. Early operation, as a preventive measure, is of great value in insuring normal function. Careful, early, and repeated inspection, with relief of undue intrinsic and extrinsic pressure, may prevent disastrous results. The physician should be on his guard to see that malposition, hematoma, flexion splints, and bandages do not impair circulation. Diagnosed a few hours after its occurrence, treatment of the fracture should be abandoned and all attention paid to improvement of the circulation. Conservative treatment, consisting of gradual extension and physical therapy, gives excellent results. Long-standing, severe cases may require surgical intervention, such as tenoplasty, arthrodesis, or neurolysis.

C. G. Sutherland, M.B. (Tor.)

DIAPHRAGMATIC HERNIA (DIAGNOSIS)

Diaphragmatic Hernia. Robert Lee Sanders. Ann. Surg., March, 1930, XCI, 367.

Sisk computes that approximately a thousand reports of cases of diaphragmatic hernia have been published since 1920. Prior to the use of the roentgen rays, cases were seldom diagnosed until operation or necropsy. The general symptoms are at best bewildering. A history of trauma is not necessary, as congenital types are manifested at any age.

If developmental failure occurs before the membranous diaphragm is complete, the defect will be total and the thoracic and abdominal cavities will be in free communication. The hernia will be without a sac—the so-called "false hernia." Later, during the formation of the muscular diaphragm, a layer of apposed pleura and peritoneum will separate the cavities, and will form a sac for the ascending abdominal viscera. The first type is formed probably during intra-uterine life and the symptoms appear late. In the second, herniation may not take place until long after birth, and if small, it may never occur.

If no history of trauma or penetrating wound is obtained, the hernia is probably congenital. Hedblom believes the term "acquired" is preferable for hernias that take place slowly. Congenital and traumatic hernias are more frequent through the left half of the diaphragm. The author quotes a case reported by Jansen in which the entire right leaf of the diaphragm was absent.

The etiology of acquired types is discussed. Gunshot, shell, and stab-wounds of the diaphragm, compression of the thorax and epigastrium, with sudden increase in intra-abdominal pressure, accidental cutting during thoracic operations and rib-resections, are listed among the causes.

Until routine roentgen examination of every baby is made we shall not know how frequent congenital diaphragmatic hernia really is. Many cases are not diagnosed because symptoms are not severe and no examination is made.

Combined abdominal and thoracic approach probably expedites the operation and makes it easier and safer for the patient. Diaphragmatic hernias should be operated on, except cases of esophageal hiatus hernia, with a short esophagus, in which repair is impracticable. Repair is dangerous during pregnancy. In cases treated surgically, a 5 per cent recurrence is found by the author.

F. B. MANDEVILLE, M.D.

Non-traumatic Diaphragmatic Hernia. Joseph F. Elward and Laurence S. Otell. Am. Jour. Roentgenol. and Rad. Ther., December, 1929, XXII, 535.

While the patient with non-traumatic diaphragmatic hernia may be without symptoms, he is more apt to have symptoms closely simulating gall-bladder disease or ulcer, hence, the writers emphasize the necessity of care in excluding diaphragmatic hernia when ulcer and gall-bladder disease have been excluded. The theories of congenital abnormality in the development of the omental bursa or closure of the pleuroperitoneal membranes, as well as the theory of acquired hernia through oft-repeated intra-abdominal pressure, are discussed. In one of the cases the patient's symptoms became more marked following an attack of whooping cough. While commonly such hernias are through the esophageal hiatus, they may be anterior, central, or posterior, one of the cases reported being that of a portion of the transverse colon through the central opening. The authors' six cases occurred in a series of approximately 400 gastro-intestinal studies.

J. E. HABBE, M.D.

Diaphragmatic Hernia: Phrenic Nerve Stimulation under Fluoroscope as an Aid in Diagnosis. Richard H. Overholt. Ann. Surg., March, 1930, XCI, 381.

There are six diagnostic methods of value in establishing a differential diagnosis between diaphragmatic hernia and eventration. They are, namely, movements of the costal margins,

roentgenoscopic signs, intragastric pressure signs, pneumoperitoneum, laparotomy, and faradization of the phrenic nerve.

A case of diaphragmatic hernia in a girl twenty-two years of age is presented. Two well known roentgenologists studied the case. Fluoroscopic and antero-posterior and lateral roentgenograms were obtained. The first made a diagnosis of eventration of the left dome of the diaphragm; the second called it a hernia.

A review of the literature in these two conditions is made by the author. The inaccuracy of some of the well known fluoroscopic signs, such as paradoxical movements, position and contour of the diaphragmatic domes, is discussed. The importance of fluoroscopic observation of a barium meal, and the need of repeated examinations are emphasized.

The author finds that faradization of the phrenic nerve and fluoroscopic observation of the dome of the diaphragm, at the same time, is of value in the differential diagnosis. In eventration, the faradization of the nerve fails to cause a contraction. In hernia, a response of the diaphragm can be seen under the fluoroscope.

F. B. MANDEVILLE, M.D.

DIATHERMY

Therapeutic Fever Produced by Diathermy, with Special Reference to Its Application in the Treatment of Paresis. J. Cash King and Edwin W. Cocke. South. Med. Jour., March, 1930, XXIII, 222.

Since the introduction of malarial infection for the production of therapeutic fever in treating paresis, effort has been made to produce the desired temperature curves without giving the patient another disease, which is not always easy to eradicate. These authors describe the method of producing such temperatures by diathermy, using a specially designed apparatus capable of generating from 3,000 to 6,000 milliamperes. This is applied to the body by means of large 7 by 9 inch electrodes, the patient being wrapped in rubber sheets and blankets to prevent too rapid dissipation of the heat. The advantages of such a method are obvious; it is always available and under accurate control, no foreign organism is introduced into the patient, the desired elevations can be produced in all patients, and drug therapy can be used in conjunction. More than twenty patients have been treated so far, all with verified diagnoses of paresis. The results compare favorably with the malarial infection method.

W. W. WATKINS, M.D.

DOSAGE

Radiosensitivity during the Reaction Period. Alessandro Vallebona. Atti del Raduno Radiologi Alta Italia, October, 1928, VI, 295.

This is a comparative study of skin erythemas produced by the same quantity of radium radiation given in one or two stages, and at different intervals. The skin reaction, due to fractional dosage, is always less pronounced, with the exception of the case in which the second application is given fifteen days after the first. The author, owing to the restricted experimental data, does not draw any final conclusions, but emphasizes the importance of administering fractional doses in the definite period of maximum sensitivity which follows the first treatment.

L. MARINELLI.

Calculations of Tissue Dosage in Radiation Therapy: A Preliminary Report. Hayes E. Martin and Edith H. Quimby. Am. Jour. Roentgenol. and Rad. Ther., February, 1930, XXIII, 173.

The authors have studied a series of ten mouth and throat malignancies in which the size and location of the primary tumors and metastases could be determined with fair accuracy. They next attempted to determine exactly the amount of radiation delivered to the tumor, which, in most instances, was treated by combined gamma rays of radium

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EXPERIMENTAL STUDIES

The Radiation and Heat Reaction of the Skin. Third Communication. The Relation between Pigmentation and Protection against Heat Rays. Philipp Keller. Strahlentherapie, 1930, XXXV, 353.

In this third article, Keller reports the results of his experiments concerning the effect of pigmentation in the skin on the temperature increase following exposure to visible and infra-red heat rays. He comes to the conclusion that pigmentation does not offer a protection against heat rays. Blackening of the skin with India ink does not influence the temperature during irradiation. However, there is a definite difference between infra-red rays of long wave length, infra-red rays of short wave length, and visible rays. Following exposure to visible light, the surface temperature of the pigmented skin is increased, due to increased absorption. The effect of infra-red rays of long wave length is not influenced at all by pigmentation.

E. A. POHLE, M.D., PH.D.

FOREIGN BODIES

Pneumotenon: A New Means of Demonstrating the Spatium Interfasciale Tenoni and the Posterior Sclera by a Combination of Contrast Media. Robert Sandera. Röntgenpraxis, Feb. 15, 1930, II, 175.

The difficulties in exactly localizing retrobulbar foreign bodies are emphasized, especially the fact that the foreign body may move with the bulbus. By injecting air and a small amount of lipiodol into Tenon's space, the bulbus itself could be demonstrated clearly, and the foreign body definitely shown to be outside the posterior sclera in the retrobulbar tissue.

H. W. HEFKE, M.D.

A Simple Apparatus and Method for Readily Determining the Exact Location of Radiopaque Foreign Bodies in the Eye or Orbital Region, by Radiography. D. B. McGrigor. Brit. Jour. Radiol., March, 1929, II, 136.

The apparatus consists of an adjustable frame, similar to the ordinary spectacle-testing frame, which acts as a film holder and cross-wire cassette. With the patient supine and the head fixed, two postero-anterior exposures are made with the previously centered undertable tube being shifted 3 centimeters to either side of the central position in order to produce the shadow shift necessary for final calculations based on geometric triangulation.

The article is accompanied by graphs and charts to aid in a complete understanding of the method, but the author takes for granted that the reader has an understanding of the original Mackenzie Davidson method.

J. E. HABBE, M.D.

GALL BLADDER (NORMAL AND PATHOLOGICAL)

A New Combined Technic for Radiological Exploration of the Gall Bladder. M. Roses Artau. Am. Jour. Surg., March, 1930, VIII, 661.

The author combined the non-surgical biliary drainage with cholecystography and with the barium meal for the gastro-intestinal tract, and in this way he obtained information on the following points: (1) permeability of the common duct and a functional test; (2) cytological characteristics of the bile; (3) bacteriology; (4) permeability of the cystic duct; (5) morphology of the gall bladder, anatomical relations, and adhesions; (6) presence or absence of gallstones.

H. P. DOUB, M.D.

Pharmacodynamic Effects upon the Gall Bladder. Alexander L. Bassin and Lester R. Whitaker. New Eng. Jour. Med., Feb. 13, 1930, CCII, 311.

The study of the effects of drugs upon motor activity of the gall bladder has been made possible by the development of cholecystography. In a long series of experiments

upon animals, profusely illustrated by serial roentgenograms, it was found that—

(1) Smooth muscle stimulants, barium chloride, pituitrin, and lead acetate produced definite but slight contraction of the viscus.

(2) Olive oil emulsion and egg yolk intravenously produced expulsion of the contents of the gall bladder, more pronounced than with any other substance.

(3) Rapid and vigorous but momentary expulsion of the contents of the vesicle was produced by "cholecystokinin."

(4) Ergotamine produced slight emptying of the gall bladder in some of the experiments. Physostigmine not only failed to produce emptying, but checked this when it had been started. Atropine ordinarily inhibited emptying.

(5) Calomel and magnesium sulphate administered by stomach tube had no effect, and magnesium sulphate intravenously produced only slight activity.

(6) Fats, in emulsion, either by mouth or intravenously, appeared to be the most constant and effective means of evacuating the gall bladder. This could be produced while the animals were under barbital and occasionally while under light ether anesthesia.

W. W. WATKINS, M.D.

Cholecystography. John F. McCullough. Penn. Med. Jour., March, 1930, XXXIII, 378.

Because of the wide differences in technic employed by various workers, there are bound to follow variations in results. Time alone will bring about the standardization which is desirable. Cholecystography has placed the diagnosis of gallstones on a very accurate basis, and when properly employed as a part of the clinical evidence, it constitutes one of the most valuable diagnostic procedures introduced in recent years. The pathologic manifestations generally agreed upon are: (1) demonstration of stones by the negative densities; (2) absence of the gall-bladder shadow, when the technic is accurate and carefully checked, has a definite significance, denoting

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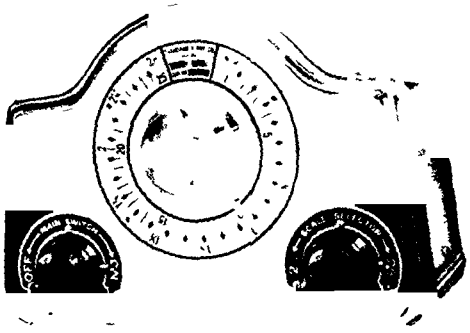
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W. W. WATKINS, M.D.

The Clinical Value of Cholecystography. R. T. Wilson. South. Med. Jour., April, 1930, XXIII, 345.

In a series of 2,112 cholecystographies, 1,132 were classified as non-calculous cholecystitis, with 106 having associated calculus formation, being 58.6 per cent of the cases examined. In 139 out of 163 patients who had cholecystectomy, 85.3 per cent gave positive roentgen-ray evidence of gall-bladder disease. The oral administration is the method of choice. It has the advantage of ease and simplicity of administration, practically no contra-indications, and no systemic reactions. Irregularity in the cholecystogram has significance. The recognition of calculi is possible with a high degree of accuracy. In the patients in whom calculi were found at operation, 94.1 per cent had been detected by the X-ray examination.

W. W. WATKINS, M.D.

GASTRO-INTESTINAL TRACT (DIAGNOSIS)

The Etiology of Diverticulitis. J. P. Lockhart-Mummery. The Lancet, Feb. 1, 1930, CCXVIII, No. 5553, p. 231.

This article is a most interesting contribution to our present knowledge of diverticulitis, and the author presents some very reasonable conclusions regarding the etiology and development of diverticulitis. He emphasizes the fact that multiple diverticula occur practically only after middle age and believes that the type causing diverticulitis is definitely not congenital in etiology. His reasons for believing this are, namely, the age of occurrence, and the fact that since cases have been followed with roentgen examinations over long periods it has been seen that diverticula

often develop in areas of the colon, which were previously of normal appearance. The author discusses the relation of diverticula to inflammation, and describes the earliest stage he has noted, that of large numbers of millet-seed projections on the outside of the colon, arranged in rows along the longitudinal muscle bands, at points where the lymphatic and blood vessels perforate the muscular coat. He feels that the diverticula start as pulsion herniations of the mucous membrane at the blood vessel foramina. He also notes that the condition is practically never present in thin persons.

Secondary inflammatory changes in diverticulous colons may occur at an early stage and produce fibrosis, or they may not occur until late in the development of the diverticula, or they may never manifest themselves.

M. J. GEYMAN, M.D.

The X-ray Study of the Large Intestines. George C. McElfatrick. Delaware St. Med. Jour., February, 1930, II, 26.

This paper and demonstration was intended to show how certain diseases of the large intestines are often confused with diseases of the stomach. Many symptoms ordinarily associated with ulcer and carcinoma of the pylorus and ulcer of the duodenum may occur, also from intestinal involvement, such as pain two or three hours after meals (relieved for a short time by taking light food), loss of weight, fatigue, gas and indigestion, gas and vomiting, heart pains, and constipation. A number of films were shown illustrating intestinal lesions which caused stomach symptoms.

W. W. WATKINS, M.D.

Some Cases of Congenital Anomalies of the Intestines. Dino Tartagli. La Radiologia Medica, March, 1930, XVII, 251.

This is a report on nine cases observed by the author, who compares the different embryological and anatomical analogies existing among them, to the characteristics revealed by radiological examination. These seem to have a common origin, although they show a totally different evolutive impulse. Some ectopies of the third portion of the duodenum are compared and reviewed by the author, who concludes by referring to discrepancies existing between clinical symptomatology and radiological verification.

L. MARINELLI.

Duodenal Hunger Contractions. Editorial (Current Comment). Jour. Am. Med. Assn., March 15, 1930, XCIV, 797.

This editorial comments on the researches of Carlson in Chicago and of Cannon in Boston and their assistance in formulating the now widely accepted dictum that hunger is due to pronounced motor activity of the stomach. Recently, Quigley and Solomon of the University of Chicago have observed "vigorous duodenal contractions during a period of complete gastric rest." Hunger sensations were reported at the same time. The conception of hunger sensations must, therefore, be enlarged to include the effects of duodenal contractions as well as the more familiar—and probably far more common and characteristic —changes in gastric motility.

C. G. SUTHERLAND, M.D.

The Roentgen Findings in Gastritis. Gustav Velde. Röntgenpraxis, April 1, 1930, II, 289.

The hope that roentgen examination would be able to make a definite diagnosis of gastritis in every case has not been fulfilled. A widening of the gastric rugæ alone is not enough for this diagnosis. Their width depends also on the tonus and the state of contraction of the muscularis mucosæ, as Gutzeit has shown. Definite gastritis, shown by gastroscopy, could not always be demonstrated by roentgenological examination. A negative X-ray examination does not exclude a gastritis. A definite diagnosis can be made when the rugæ are very markedly widened, and especially if the mucous membrane appears

granulated. A narrowing of the rugæ should not be interpreted as atrophic gastritis. The possibilities of error in the roentgen diagnosis of gastritis are great, and one should not read too much into the roentgenological picture of the gastric mucous membrane.

H. W. HEFKE, M.D.

Papilloma of the Duodenum. Milton R. Bookman. Ann. Surg., April, 1930, XCI, 626.

The author reports a case of papillary adenoma of the duodenum in a woman 39 years of age. The main findings in this case and others reviewed by the author were, blood appearing in the stools and well mixed with food residue, but without definite concomitant clinical signs of ulcer. Occasionally some degree of jaundice is associated with this condition. Such adenomata spring from the mucous membrane about the papilla of Vater.

Balfour and Henderson recently gathered the records of 131 benign growths of the duodenum. Golden has presented a collective review of 19 cases of papillomata of the duodenum, which included two of his own cases.

No roentgen-ray studies were made in the case outlined by the author. He states, however, that the roentgen rays give a fairly definite picture when it is obtainable, and he concludes that, in the face of active and massive bleeding, a well administered barium meal is less dangerous than the rather blind exploration of the abdomen in the hope of finding a source of the bleeding.

F. B. MANDEVILLE, M.D.

The Relationship of Duodenal Diverticula to Diseases of the Liver and the Bile Ducts. W. Stepp and K. Gutzeit. Med. Klin., April 4, 1930, p. 495.

Although many duodenal diverticula are symptomless and of no clinical importance, some, especially if large, may cause definite symptoms. Two cases are described in which fairly large diverticula were found roentgenologically. In both of these, pressure of the diverticulum led to obstruction of the bile ducts, icterus, and liver damage. The correctness of the diagnosis was corroborated by surgery in one case, and by autopsy in the other. The roentgen examination makes it possible to decide whether dietetic treatment or operation is indicated. Even after exact localization of the diverticulum by roentgenologic examination it is often difficult for the surgeon to find it. The duodenum occasionally requires opening, especially when the diverticulum is situated posteriorly. By resecting the diverticulum it is often possible to make the patient symptom-free and to prevent further damage to the bile ducts and the liver.

H. W. HEFKE, M.D.

Roentgen Diagnosis in Intestinal Obstruction. Sch. Samuelson. Röntgenpraxis, April 1, 1930, II, 297.

The X-ray examination of the abdomen without contrast media is not used often enough in cases of clinically suspected intestinal obstruction. It gives early evidence of the presence of obstruction and often, also, its seat. Gas bubbles and fluid levels in the small bowel are absolutely diagnostic and are found as early as two hours after the onset. Only rarely is it necessary to exclude a lesion in the colon by a barium enema. Examination without contrast media should be made with the patient standing, or lying on one side, preferably the former. The author describes seven cases and emphasizes the early roentgen examination in all cases of clinically suspected intestinal obstruction. The X-ray findings are much more reliable than any other clinical examination.

H. W. HEFKE, M.D.

Non-rotation of the Colon. Lon W. Grove. Ann. Surg., April, 1930, XCI, 615.

A case of non-rotation of the entire colon in a male 27 years of age is presented. Left-sided abdominal pain, with peculiar attacks of diarrhea following meals, were the main symptoms. Fluoroscopic and radiographic

studies demonstrated the cecum, the ascending and transverse portions of the colon to be joined together by adhesions and to be to the left of the median line.

At operation, X-ray findings were confirmed, and the portions of the colon mentioned above were found adherent to the duodenum and part of the jejunum, by a thin membrane. A colopexy was done according to the Coffey technic. A barium enema one and one-half years after operation showed the colon to be in normal position.

F. B. MANDEVILLE, M.D.

Fundamentals in Roentgenology of the Colon. James T. Case. Am. Jour. Surg., April, 1930, VIII, 844.

In this communication the author takes up the fundamentals describing the roentgen anatomy of the colon, including the mobility of various segments. Various formulas for opaque meals and enemas are given. The technic of injection of the enema, together with the apparatus necessary, is fully described.

This article is well adapted for beginners in roentgenology, going into the fundamentals in considerable detail.

HOWARD P. DOUB, M.D.

Diverticulitis of the Colon. Fred W. Rankin and Philip W. Brown. Surg., Gynec. and Obst., May, 1930, L, 836.

The history, etiology, pathology, and classification are discussed in this article. Under the symptoms, constipation was present in 60 per cent, diarrhea alone in 11 per cent, and tumefaction in 31 per cent. The diagnosis is chiefly roentgenological by a barium enema observed under the fluoroscope. Diverticula manifest themselves as rounded knob-like projections from the lumen of the colon, and show considerable variation in size. Sigmoid segment is the favored site, with diverticula becoming less numerous as the examination proceeds proximally. The roentgenological evidence of diverticulitis is that of spasm and hypermotility.

Differential points of diagnosis.—In diverticulitis concentric contours of the segment, maintenance of mobility, and a rather long segment of the colon are noted, while in carcinoma contours are sharply irregular, immobility is present, and there is a much shorter segment involved. Medical and surgical treatment are discussed and the following summary and conclusions are given:

1. Diverticulosis is quite prevalent, apparently occurring in about 5 per cent of persons who have symptoms referable to the large bowel, but probably actually occurring in about 1 per cent of all persons.

2. Diverticulitis probably occurs in about 17 per cent of cases of diverticulosis and in most instances is chronic in its course and subject to exacerbations.

3. The etiology of diverticula is obscure, but they are probably the result of several factors, among them inherent muscular weakness in the wall of the bowel and environmental conditions, obesity, and constipation.

4. Diverticulitis probably is the result of improper emptying of the bottle-shaped sacculations, with subsequent inflammatory reaction, necrosis, and occasional perforation.

5. The relationship of diverticulitis to carcinoma probably is incidental rather than actual.

6. In 227 cases reviewed in this paper, as treated at the Mayo Clinic, a malignant condition was found associated in four only.

7. Diverticulitis occurs almost entirely in persons of middle age who are inclined to be corpulent and who lead sedentary lives. Diverticulitis usually runs a chronic course with several exacerbations and yields satisfactorily to dietary and medical treatment.

8. The outstanding symptom of diverticulitis is pain, usually situated in the lower left portion of the abdomen, and is frequently associated with constipation. Change in bowel habit is a confusing factor.

9. Bleeding is not commonly found among the symptoms of uncomplicated diverticulitis or diverticulosis. When it does occur, an associated malignant condition is always suspected, but frequently not found.

10. Tumefaction associated with diverticu-

litis is common and usually is the result of inflammatory reactions, with or without formation of the abscess. In itself, it does not indicate associated malignancy.

11. The medical treatment of acute diverticulitis consists of a "watchful waiting" while the patient is at rest in bed and is given irrigation of the affected segment of bowel with warm sodium chloride solution and other sedative solutions. As the process subsides, anti-constipation diet and the use of small doses of mineral oil, orally, are given. A dietary regimen is highly essential and probably often prevents complications.

12. In a definite percentage of cases, diverticulitis tends to become complicated. The most common complications are abscess, fistula, and perforation.

13. The treatment of the complications of diverticulitis is usually surgical, particularly of the internal fistulous formation in which a viscus, such as the bladder, is penetrated by the inflammatory process.

14. Primary resection in the face of complications and diffuse inflammation is accompanied by a relatively high mortality rate. The operation of choice is a graded procedure, consisting of drainage and subsequent resection and anastomosis.

15. Often prolonged drainage by colostomy permits complete recession of tumefactions and disappearance of clinical symptoms, rendering unnecessary further intervention.

D. S. CHILDS, M.D.

GENITO-URINARY TRACT (DIAGNOSIS)

Cystography in Infancy and Childhood. Meredith F. Campbell. Am. Jour. Dis. Child., February, 1930, XXXIX, 386.

Age is no contra-indication to cystography—an infant of six days was included in this series of 150 cystographic examinations of children. Acute urinary infection of less than four weeks' duration is the main contra-indication. Among the indications are: chronic pyuria, enuresis, chronic urinary difficulty, frequency, dysuria, vesical pain, suprapubic mass, hematuria (not due to hemorrhagic nephritis). All the unusual pathologic conditions demonstrated in the adult may be noted in the child. Intra- and extra-vesical neoplasms are, of course, rare.

A 5 per cent solution of sodium iodide is injected with a soft rubber catheter after the patient has been catheterized and an enema administered. The injection is stopped when discomfort is noted. The average amount at two years is 30 c.c., at six years, 70 c.c., and at ten years, 100 cubic centimeters. The target of the tube is centered over the pubis; flash exposures are made without a Bucky. The Trendelenburg position is not used as reflux is to be avoided.

Vesical hypotonia was uniformly observed in choreic children. All showed abnormally large cystograms. A cystogram showing lateral displacement of the bladder, the result of tuberculosis of the seminal vesicle, was included. This demonstrated the characteristic finding in extra-vesical pressure. Advanced inflammatory disease of the bladder walls was found to be more common than tuberculous processes.

Ureteral reflux was noted on one or both sides, depending on the degree of inflammatory involvement of the ureterovesical valves. The author disagrees with Kretschmer and does not believe that reflux may occur in the normal bladder. Of the 150 cases, 12 per cent showed reflux, unilateral in eight and bilateral in ten cases.

In diverticulosis, Hinman's method—the emptying of sodium iodide and refilling the bladder with air for further roentgenograms—was found to be very satisfactory.

F. B. MANDEVILLE, M.D.

Ureteral Kinks: How They Occur at the Order "Take a Deep Breath and Hold It." Gershom J. Thompson and Hermon C. Bumpus, Jr. Jour. Am. Med. Assn., March 15, 1930, XCIV, 771.

In reviewing their old pyelograms, the authors were surprised to find how frequently ureteral kinks were apparent in one and absent

in the other of two films made on one patient. It was found that a ureterogram made while the patient was holding the breath (deep inspiration) would show a ureteral kink, while one made after the patient had relaxed (deep expiration) would show a straight ureter. These cases are reported in detail.

The authors' conclusions are that kinks of the ureter may be present without symptoms; their correction by surgical measures should be delayed until urinary stasis is demonstrated.

C. G. SUTHERLAND, M.D.

Excretion Urography: A Preliminary Note on a New Method of Radiological Demonstration of the Urinary Tract. Kenneth Heritage and R. Ogier Ward. Brit. Med. Jour., April 19, 1930, No. 3615, p. 734.

Since Graham's epoch-making work on cholecystography a number of workers have been active in the search for a suitable non-toxic, yet selective excretory substance to visualize the urinary tract. Rosenow conceived the idea of combining intravenous administration of sodium iodide (the iodide equivalent of 38 grams of iodine) and urea, with subsequent radiography of the urinary tract. Recently, the work of Swick, Binz, and Raeth has resulted in the production of uroselectan.

This preparation has proved satisfactory. It is harmless even in large quantities (3 grams per kilo of body weight is tolerated by the guinea-pig); it is soluble up to 50 per cent, contains 42 per cent iodine in organic combination, and is excreted unchanged from the kidneys in sufficient concentration to give good radiographic shadows. In fact, it can be almost completely (95 per cent) recovered from the urine.

Uroselectan is given intravenously on the X-ray table, 40 grams dissolved in 100 c.c of water for an adult male. An iodide idiosyncrasy must be sought beforehand. The first roentgenogram is taken 10 minutes after injection. Further roentgenograms are taken one-half hour, one hour, and two hours after injection. After clinical observations on a series of over two hundred patients, the authors come to the following conclusions:

1. By this method of urography a roentgenogram is obtained of the whole urinary tract without instrumentation, provided both kidneys retain in some degree their excretory function.
2. The method offers a differential test of renal function.
3. The procedure is harmless.
4. The results are easily obtained, of good quality, and in most cases, leave no doubt as to the condition present.
5. There are certain contra-indications to the use of this method.
6. The method promises to be of great value in elucidating the pathology of surgical disease of the kidney.
7. Cogent indications are: impassable obstruction of the urethra or of the ureters, severe hemorrhage, multiple urinary fistulæ, "thimble bladder" in the case of small children, or in cases of implantation of the ureters into the bowel. In prostatic hypertrophy, with intravesical projection rendering ureteric catheterization both difficult and inadvisable, the intravenous method will also find a place.
8. The exclusion of latent uremia by blood urea examination is an important preliminary.

H. W. DUNDAS MACKENZIE, M.D.

Recent Advances in the Renal Surgery of Childhood. R. I. Harris. Can. Med. Assn. Jour., March, 1930, XXII, 358.

The recent introduction of special cystoscopes of small size has permitted, for the first time, investigation of the genito-urinary tract of children with the same completeness that for many years has been possible in adults.

The commonest lesion of the urinary tract in children is that termed "pyelitis." In a few cases of the chronic type of this condition the author found no signs of obstruction or dilatation of the urethra, bladder, or ureter. The kidney pelves were normal and pyuria was frequently unilateral. Examination of a kid-

ney removed at operation showed the condition to be a pyelonephritis, and not a pyelitis.

A great many cases of so-called pyelitis were found to be cases of urinary infection behind a mechanical obstruction. These obstructions were found in the urethra and ureters. The urethral obstruction was found only in males and was due, in most cases, to congenital valves in the prostatic urethra. Occasional stricture of the male urethra was found. Ureteral obstruction was found in both male and female.

The paper is well illustrated with pyelograms.

L. J. CARTER, M.D.

GYNECOLOGY AND OBSTETRICS

On Light and Heat Therapy in Gynecology. Wilhelm Flaskamp. Strahlentherapie, 1929, XXXII, 672.

This is a well illustrated article describing the equipment and methods used in the Erlangen Clinic for light and heat treatments. A considerable number of gynecological diseases lend themselves successfully to physical therapy. A very careful procedure has been worked out in each case, requiring patience from both physician and patient. The article is recommended for study in the original.

E. A. POHLE, M.D., PH.D.

The Present Status of Gynecological Radiotherapy. Michael Bolaffio. Strahlentherapie, 1930, XXXVI, 201.

The author gives a brief résumé of his report made before the last Annual Meeting of the Italian Society of Gynecology and Obstetrics. The article does not lend itself to abstraction but it should be looked up, however, in the original, for two reasons: in the first place, one gains a rather complete impression of the status of radiotherapy in Italian gynecological clinics, and the synopsis of the discussion following the reading of the paper brings out very clearly the conception and difference in opinion of the various schools.

ERNST A. POHLE, M.D., PH.D.

HEART AND VASCULAR SYSTEM (DIAGNOSIS)

Vertebral Erosion Due to Aneurysm. Antonio D'Istria. La Radiologia Medica, January, 1930, XVII, 1.

The author states the difficulties the radiologist encounters in the diagnosis of aneurysm of the descending aorta. In order to establish the general features of vertebral erosion due to aneurysm, the author analyzes the results obtained in five cases in which the diagnosis was confirmed at autopsy. They may be summarized as follows: multivertebral lesions of generally round contour, more marked at the center of each vertebra, with a tendency to spare vertebral discs; normal structure of the vertebral part not affected. The author mentions the diagnostic details which differentiate other osteo-destructive diseases, and concludes that the mechanical theories are the most apt to explain the effects of aneurysm.

L. MARINELLI.

HODGKIN'S DISEASE (DIAGNOSIS)

Hodgkin's Disease of the Lungs. A. Held. Fortschr. a. d. Geb. d. Röntgenstr., February, 1930, XLI, 191.

Malignant granuloma (lymphogranulomatosis or Hodgkin's disease) may cause a great variety of pictures within the thoracic cage, other than swelling of the lymph nodes. Four types of intrathoracic pathology due to this disease are described: (*a*) simple mediastinal lymphatic tumors; (*b*) mediastinal tumors with direct extension into pulmonary tissue; (*c*) independent pulmonary processes associated with mediastinal tumors; (*d*) disseminated pulmonary form. A number of case reports illustrate the different types, some of which closely resemble tuberculosis. The association of lymphogranulomatosis with tuberculosis, however, is rare. Diagnostic irradiation may help in differentiating between the two types of infection. Occasionally cases

have been observed with lymphogranulomatosis upon which previously a diagnosis of pulmonary tuberculosis was made because of pulmonary symptoms, until the roentgenologic examination revealed the nature of the pathology. A differential diagnosis is not usually complicated by results of bronchostenosis and pulmonary atelectasis, with or without secondary infection. The response to radiation treatment is usually very prompt. A histologic diagnosis cannot be made from irradiated lymphatic tumors or tumors which undergo frequently occurring regressive stages.

H. A. JARRE, M.D.

Concerning Lymphogranulomatosis (Hodgkin's) of Bones. H. Friedrich. Fortschr. a. d. Geb. d. Röntgenstr., February, 1930, XLI, 206.

This is the report of a case of Hodgkin's disease of the mandible in a young adult. The bone showed considerable enlargement with a coarse irregular honey-combed structure. Enlarged cervical lymph nodes were found associated with the bone tumor. The diagnosis was made, histologically, on one of these lymph nodes which was removed. A small piece of bone removed for histologic examination revealed signs of marked new bone formation, associated with marked bone resorption. The pathologist thought it best to correlate this picture with a diagnosis of osteitis fibrosa, but remarked that a correct diagnosis may not be possible. This bone tumor responded very readily to radiation treatment, but the patient succumbed to the disease within two and one-half years. The author points out that a differential diagnosis from osteitis deformans could not be made roentgenologically, but only on histologic examination of one of the enlarged lymph glands. Very few cases of Hodgkin's disease of the bones are reported in the literature, and a communication of further cases is requested.

H. A. JARRE, M.D.

HODGKIN'S DISEASE (THERAPY)

Concerning the Prognosis in Hodgkin's Disease. B. Kuhlmann. Strahlentherapie, 1930, XXXV, 296.

It is generally accepted that the average expectancy of life after the onset of the symptoms is about two and one-half years. However, instances are on record in which the patient lived up to thirteen years and responded well to radiation therapy. The author relates the history of a patient sixteen years of age who came under observation in April, 1923. He complained of shortness of breath at that time, and there were tumors of hen's egg size in both parotid regions. Smaller glandular enlargements could be palpated in both supraclavicular regions and in the left groin. The roentgenogram of the chest showed enlargement of both hili. Biopsy verified the clinical diagnosis. Small doses of roentgen rays (one-third E.D.) at 190 K.V., filtered through 0.5 Cu plus 1.0 Al, were given at about six week intervals. At the same time, the patient received ultra-violet therapy over the body. At present, that is, over six years after the onset of the disease, the patient is well and without clinical manifestations of the disease.

E. A. POHLE, M.D., PH.D.

The Treatment of Lymphogranulomatosis. J. Jacobs. Strahlentherapie, 1930, XXXV, 533.

X-ray therapy of Hodgkin's disease is recommended to be applied only to the diseased glands. A conservative procedure is indicated because large doses may lead to intoxication. It is also to be considered that a chronic disease of this nature will require repeated treatments and large doses are not practical because of the lessened skin toleration. The best procedure is undoubtedly to find out the minimum dose required in each case for response. As a rule 30 to 50 per cent of the erythema dose with heavily filtered radiation should suffice. The author also used, with advantage, the intravenous injection of dextrocid which is an iodin-cer compound coupled to a

30 to 50 per cent dextrose solution. A few cases are reported, illustrating that the tumors apparently respond better under this combined treatment.

E. A. POHLE, M.D., PH.D.

LIGHT THERAPY

The Finsen Treatment of Small-pox. C. H. Würtzen. Strahlentherapie, 1930, XXXVI, 311.

On the Finsen Treatment of Small-pox. Leopold Freund. Strahlentherapie, 1930, XXXVI, 320.

Würtzen discusses the treatment of small-pox as proposed by Finsen, who excluded all chemically active rays from the sick-room. This can be done by covering the windows with red cloth or by using a red glass. The results were good in certain clinics and disappointing in others.

In the discussion, Freund emphasizes the statement that it is not possible to filter out all chemically active rays, and he suggests, therefore, the designation of this treatment method as the "red room treatment." Upon his recommendation, an ointment containing 6.5 per cent rapid filter red was tried out on small-pox lesions, not covered by clothing. This was, however, without success.

ERNST A. POHLE, M.D., PH.D.

MEASUREMENT OF RADIATION

Concerning Roentgen Dosimetry in Dermatology. Franz Thedering. Strahlentherapie, 1930, XXXVI, 127.

Concerning Roentgen Dosimetry in Dermatology. G. Schulte. Strahlentherapie, 1930, XXXVI, 132.

Thedering recommends extremely small doses in the treatment of skin diseases. He administers from 0.1 x to 0.3 x, 8 inch spark gap, 0.5 mm. to 3.0 mm. Al. In his experience, the results have been most favorable and there is no danger of late reactions.

Schulte does not agree with this point of view and urges the retention of the fractional method, applying about one-third of a skin unit every ten days. He has never seen any late reactions even after the application of three full skin units during a period of fifteen months. An examination of the skin capillaries before repeating the treatment seems, however, advisable in the light of our present knowledge.

ERNST A. POHLE, M.D., PH.D.

Dosimetry in Radiological Diagnostics. Arduino Ratti. Atti del Raduno Radiologi Alta Italia, October, 1928, VI, 233.

This is a comparative analysis of the radiation emitted by three diagnostic tubes of different make, having the same rating and used under identical conditions. Important discrepancies in both quality and quantity of the output were noticed, and the author points out that, while they have practically no effect on either the radiographic or radioscopic image, they must be considered, especially in radioscopy, in relation to the safe limit of radiation that the skin can absorb. The routine use of aluminum filters from 0.5 to 1 mm. thickness is recommended.

L. MARINELLI.

MEDICAL PRACTICE

Radiation Service in the Modern Hospital. Albert Soiland and Orville N. Meland. Jour. Am. Med. Assn., Jan. 25, 1930, XCIV, 239.

In modern hospitals there has been an endeavor to increase radiologic efficiency. These authors discuss the accomplishments of irradiation in the various ills to which man is disposed. A separate department with its own equipment is essential if a great deal of treatment work is to be done. It is better to have good irradiation from an X-ray installation than to have inadequate radium or radium

therapy in the hands of the inexperienced. Granting the radiologist has the training and experience, he should keep his associates informed as to the possibilities in his particular line.

C. G. SUTHERLAND, M.B. (Tor.)

OFFSPRING, EFFECT ON

Post-conception Pelvic Irradiation of the Albino Rat (Mus Norvegicus): Its Effect upon the Offspring. Douglas P. Murphy and Marguerite De Renyi. Surg., Gynec. and Obst., May, 1930, L, 861.

The irradiation was given with equipment of the mechanically rectifying type, energizing a broad-focus Coolidge tube. The roentgen machine was calibrated with a Wulf ionometer, the latter in turn calibrated in Germany with the proposed international r. The operating factors were as follows: 127 K.V. (peak); 5 ma.; 30 cm. skin target distance, and 6 mm. of aluminum. One hundred and eighty milliampere-minutes (ma.-min.) of exposure gave 800 r of intensity. With this technic, 120 animals were subjected to from 1 to 6 exposures, varying in strength from 45 to 360 ma.-min. (200 to 1,600 r).

Gestation in the rat consumes from 22 to 23 days. Of the 120 treated animals, 34 cast litters within less than 22 days of their last roentgen exposure, *i.e.*, the embryos in these cases had received at least one roentgen exposure. The litters of these 34 animals varied in size from 1 to 11, the most common being 2, with an average size of 3.6 young. In a group of 35 control litters the most common size was 7 young. Grossly defective young were cast by 5 of the 34 irradiated animals. The number of these young appeared to be in direct proportion to the degree of the irradiation. These litters comprised a total of 13 offspring, of which 2 were known to be alive at birth but died within a few hours. The remaining 11 were either stillborn, or were killed by their parents, or died natural deaths before being observed. Of the whole group of 13 young, 6 exhibited developmental defects of the extremities.

Of the 5 animals casting litters containing defective young, 4 gave birth to a total of 10 offspring, all of which were, at least externally, well formed, except for a foot deformity exhibited by 5 of them. The foot abnormality exhibited by these 5 young was characterized by lack of the normal depth of the digital grooves. In 4 of the 5 animals only the hind feet were affected, while the fifth one exhibited the defect in all four feet. Where the digital grooves were absent or distorted, the entire foot was deformed so as to appear clubbed. In a number of instances the end of the extremity was perfectly smooth, similar in appearance to an amputation stump of long standing. In those instances in which only the hind feet were affected, the fore feet appeared to be perfectly normal in every respect.

The fifth litter consisted of only one young. This animal appeared to be perfectly healthy and lived until the end of the experiment. Its fore feet, however, had only three well developed toes each, with the normal site of the missing toe marked by a rudimentary bud which suggested an arrest of development.

It is believed that the abnormalities which have been described are the result of the embryonic irradiation. The clinical findings suggest this as does also the earlier experimental evidence advanced by other workers. In the case of the present experiment, the defects varied (at least in frequency) with the degree of the embryonic exposure. The same defect was observed several times in the same litter and in more than one litter.

It is significant that the deformities observed among the young of animals irradiated when pregnant have not been duplicated in a series of 125,000 non-irradiated control animals.

D. S. CHILDS, M.D.

PROTECTION

Is the Radiologist a Public Danger? British Medical Journal Correspondent (France). Brit. Med. Jour., Nov. 30, 1929, No. 3,595, p. 1026.

In France a newspaper campaign was

started in the lay press against the "terrible danger" of X-rays to the public and especially to those persons who live in the immediate neighborhood of a radiologist. The argument was purely theoretical, and no proof whatever was offered. As Dr. Maingot ably replied, not only do we prevent the rays escaping from our rooms, but we prevent them escaping into our rooms, and the radiologist works in an X-ray proof atmosphere. This information, spread to the public through the press, has prevented a panic which might have proved most prejudicial to the specialist.

W. D. MACKENZIE, M.D.

Better Protection in Vertical Fluoroscopy. J. Belot. Am. Jour. Surg., April, 1930, VIII, 859.

The author states that the three dangers present in vertical fluoroscopy are: first, danger of electrocution; second, danger from direct irradiation, and third, danger from absorption of secondary rays.

He describes a fluoroscope which he has had constructed and which he believes gives complete protection to the radiologist in these regards. In this, the tube and all high tension wires are situated in another room and the field of rays is thoroughly shielded.

HOWARD P. DOUB, M.D.

RADIATION SICKNESS

Activated Ergosterol in Radiation Sickness. Lester A. Smith. Am. Jour. Roentgenol. and Rad. Ther., October, 1929, XXII, 317.

Fifty-five cases undergoing intensive roentgen or radium irradiation were simultaneously given activated ergosterol in four to eight minim doses two or three times daily. All but ten of these patients were completely relieved of nausea. Seventeen of them had had previous series of treatments without ergosterol, under such conditions showing radiation sickness. In many cases the patients described a sensation of unusual well-being and a great improvement in appetite. The effect is believed to be brought about by altering the calcium-phosphorus metabolism.

J. E. HABBE, M.D.

RADIUM

A Case of Granuloma Annulare Cured with Radium. C. J. Broeman. Jour. Med., February, 1930, X, 597.

The text-book treatment of this condition, with the exception of the X-ray, is a more or less destructive one by chemicals, leaving more or less scarring. X-ray has been mentioned by several writers as of benefit. In the case cited, 25 mg. of radium in a 0.5 mm. silver capsule and 1 mm. brass, at a distance of one-eighth inch was applied for three hours; eleven days later it was repeated for two hours, using 50 mg.; twenty-one days later, 50 mg. for two hours. Five months later the lesion was entirely cured, and the skin of the hand was perfectly normal.

W. W. WATKINS, M.D.

Modification of the Technic of External Radium Applicators. Mario Maino. La Radiologia Medica, February, 1930, XVII, 109.

The author considers the present technic of external radium application either unsatisfactory or too complicated. He advises the adoption of paraffin reinforced by a soft and homogeneous layer of absorbent cotton, having the same dimensions as the applicator. This method is simple, avoids fragility, and retains solidity and lightness. It is appropriate for long treatment and it was found not to affect, in any way, the uniformity of the radiating beam.

L. MARINELLI.

The Use of Radium in the Treatment of Uterine Hemorrhage. Gerry H. Holden. Jour. Florida Med. Assn., February, 1930, XVI, 355.

Uterine hemorrhage is not a disease but a symptom of many disorders, of which the

following are discussed as being amenable to radiation: Cancers of the uterus, myomatous tumors of the uterus, functional or idiopathic uterine hemorrhage. The bleeding from cancer of the uterus is controlled by the natural regression which takes place following radium treatment. In fibroid tumor the degree of success in stopping hemorrhage with radium will depend upon the care of selection of cases; only about 40 per cent should be treated with radium. Cases of menorrhagia and metrorrhagia without tumor formation can usually be controlled by radium radiation—whether or not the treatment is best for the individual case can be determined only after careful analysis. As a general rule, radium should be used only at or near the menopause, and where there is no pelvic inflammatory lesion present.

W. W. WATKINS, M.D.

The Effect of Radon on the Distribution of Phosphorus in Normal Dogs. Nina Kotschneff and Anna Arapoff. Strahlentherapie, 1930, XXXVI, 360.

The distribution of phosphorus in normal dogs was studied with the method of Dr. E. S. London (angiostomy method). If from 10 to 30 mc. of radon were injected into the blood stream, stomach, intestines, or gall bladder of fasting dogs, there followed a drop of the inorganic phosphorus. The same observation was made during the digesting period. A study of the phosphorus content of the blood in various regions of the body showed that the drop was most pronounced in the blood of the kidney veins.

ERNST A. POHLE, M.D., PH.D.

The Diagnosis and Treatment of Abnormal Uterine Bleeding. Archibald L. McDonald. Minnesota Med., March, 1930, XIII, 172.

After considering the bleeding due to pathologic conditions in early pregnancy, the author discusses bleeding due to local causes, under three heads. (1) Pre-climacteric hypertrophy of the endometrium, which he says should be treated by curettage. (2) Submucous or pedunculated fibroids associated with hyperemia; if curettage shows cancer not present, the author states that excision of the growth and hysterectomy is the proper procedure, and radium is not advised. (3) Cancer of the body should be treated by hysterectomy, and cancer of the cervix with radium.

(Abstractor's note: Radiologists will not agree that radium has no place in treating either Class 1 or 2 of this grouping, but insist that it has a very large place in both groups.)

W. W. WATKINS, M.D.

The Rôle of Secondary Beta Rays in Gamma-ray Therapy. A. Piccard and E. Stahel. Strahlentherapie, 1930, XXXVI, 347.

A number of interesting experiments dealing with the ionization measurements of radium preparations under various conditions are discussed, and the following conclusions presented. In all treatments with gamma rays, it is entirely superfluous to use a so-called secondary filter; in other words, it is not necessary to surround filters of platinum, gold, or brass by aluminum or rubber, for instance, because the secondary radiation is not appreciably influenced by this method. It is possible when using radium preparations (gamma rays) at distances to decrease the amount of radiation in the upper layers of the skin. This can be done by using a magnetic field or by a proper localization and arrangement of filters.

ERNST A. POHLE, M.D., PH.D.

Relative Value of Radium and X-ray Therapy in Malignant Disease. N. S. Finzi. Brit. Jour. Radiol., April, 1930, III, 161.

The author has been using radium for over twenty years and X-rays therapeutically for several years longer. With each increase in voltage and filtration improved results have been noted. Because of the further development possible with X-rays, it is believed that there will be advances made with X-ray therapy. While every case must be decided on its own merits as regards the use of X-ray or

radium or both, the following are the general conclusions of the writer:

In very radiosensitive and rapidly growing tumors, such as lymphosarcomas, X-ray therapy is always the treatment of choice.

With very small growths which tend to remain localized (for example, rodent ulcer, epithelioma of the larynx) radium is always preferable.

In radioresistant tumors, radium is the method of choice. By increasing the period of exposure from five to six weeks with daily applications, the results with either X-rays or radium are improved.

In growths of the mouth and upper air passages, X-rays alone or in combination with radium are preferred because of the greater homogeneity of the X-rays.

In tumors of the cervix, radium for the primary tumor and X-rays for the pelvic glands give the best results.

In rectal carcinoma, radium is advised.

In breast cases, radium needles give good results where such a method is suitable, but for mediastinal extension X-rays are chosen.

The skill of the radiologist varies as much as the skill of the surgeon, and skill is a large determining factor in the results obtained.

J. E. Habbe, M.D.

Concerning Radium Treatment of Malignant Struma. Fritz Dautwitz. Strahlentherapie, 1930, XXXVI, 32.

The introduction to this article offers a review of the international literature on malignancy of the thyroid, comparing the results obtained by surgery and radiation. The author has treated twenty-five cases of this type with radium (gamma rays). Surface applications containing from 40 mg. to 90 mg. of radium, at from 1 cm. to 3 cm. distance, using the cross-fire method, were employed, at an exposure per treatment of from 6 to 12 hours. This was repeated at certain intervals. The average dose for inoperable cases amounted to about 11,000 milligram-hours. In resistant malignancies, about 13,000 mg.-hrs. were used. The maximum dose given in any case in one series was somewhat over 18,000 milligram-hours. The statistical survey of the patients shows that of the fourteen inoperable ones, six died during the first year following the treatment, one each died during the second, third, and eleventh years. Fourteen years after treatment, one patient was still alive; no answer was obtained from three patients, and the cause of death of one patient could not be learned. Of the eleven patients suffering from recurrent malignant struma, three died during the first year following the treatment, one died four years later, one is alive after two years, three are alive after four years, and one each, six, eight, and twelve years following the treatment.

Ernst A. Pohle, M.D., Ph.D.

On the Theoretical Foundation of Internal Radium Therapy, Emanation Therapy, and Biologic Dosage. J. Markl. Strahlentherapie, 1930, XXXVI, 337.

The amount of emanation in the blood and in the gastric juice up to about two hours after drinking 100 c.c. of water containing 200,000 ME. (Mache units) was determined. It appeared that the individual variations were higher than those due to the influence of eating. A calculation shows that the amount of emanation found corresponds to about from 7,000 to 10,000 Alpha rays per c.c. of tissue. The possible biologic effect of such small energies is discussed.

Ernst A. Pohle, M.D., Ph.D.

RICKETS (THERAPY)

Sunlight Type S-1 Lamp (G. E.) Therapy in Human Rickets and Rachitic Spasmophilia. Henry J. Gerstenberger and G. Richard Russell. Jour. Am. Med. Assn., April 5, 1930, XCIV, 1049.

Three rachitic patients were exposed once a week in such a manner as to produce a definite erythema. In each patient a decided improvement in the blood calcium and inorganic phosphate level was recognizable after two

weeks. Normal figures were reached in from four to seven weeks. Roentgenographic study agreed with the above findings.

C. G. SUTHERLAND, M.D.

Treatment of Rickets with Irradiated Milk. Rudolf Hess. Strahlentherapie, 1929, XXXIV, 787.

Irradiated fresh milk is not a reliable agent in the treatment of rickets, according to the experience of the author. Irradiated powdered milk and irradiated ergosterol (Vigantol) compared favorably with the therapeutic effect of the radiation of the sun or of the quartz mercury vapor lamp.

E. A. POHLE, M.D., PH.D.

ROENTGEN THERAPY

Radiation Therapy of Bone Metastases in Carcinoma of the Breast. A. Beck. Strahlentherapie, 1930, XXXV, 513.

The author discusses the problem of bone metastases appearing after radical removal of carcinoma of the breast. To judge from the literature on the subject and from his own experience, X-ray therapy offers not only palliation in this type of case, but quite frequently leads to a temporary cure of the bone lesions. The histories of three cases, accompanied by roentgenograms, are briefly related, illustrating the good response of the bone metastases to X-ray deep therapy.

E. A. POHLE, M.D., PH.D.

Deep X-ray Therapy: Conclusion Derived from the Treatment of Five Hundred Cases. E. C. Thrash and W. Pope Baker. Jour. Med. Assn. Georgia, February, 1930, XIX, 58.

X-ray therapy is by no means confined to malignancies, but many other stubborn pathological conditions are amenable. Therapeutic work has been done at 200 K.V., 15 to 30 ma., distance of from 30 to 50 cm., copper and aluminum filtration, 200 to 600 milliampere-minutes. Dosage is classed as lethal, paralethal, and reactionary. Condemnation of X-ray therapy is believed to have been caused by over-treatment. The aim of the authors is not so much to remove the tumor growth in cancer, as to cause its replacement by fibrous tissue sufficient to stop its growth; arrest can often be brought about without even perceptibly diminishing the size of the tumor. Most breast cancers are primarily surgical, but in most cases X-ray treatment should be associated. Good results have followed treatment of cancers of the abdominal viscera, and success in this field is attributed to the fact that they are not over-treated. Among other conditions successfully treated are mentioned *sycosis (100 per cent), chronic scaly eruptions* of all kinds, epidermophytosis, chronic neuritis, simple bronchial asthma, and hay fever.

W. W. WATKINS, M.D.

Chloroma: Report of a Case with Recovery Following Roentgenotherapy, with a Review of the Literature. Alfred H. Washburn. Am. Jour. Dis. Child., February, 1930, XXXIX, 330.

A case of myelogenous chloroma in a boy aged twenty months, is presented. The diagnosis was established by complete blood, roentgen, and pathologic studies. A complete cure resulted, following roentgen therapy, which has lasted for two and one-half years. Roentgenograms before and after treatment are included.

The author recognizes a myelogenous and a lymphatic type of chloroma. His review of the literature from 1823 to June, 1929, revealed 162 cases of chloroma and 20 additional doubtful cases. Most of the recent cases have been of the myelogenous type, and there is evidence which indicates that chloroma is a form of myelogenous leukemia.

Treatment consisted in a relatively long course of small doses, lasting over a period of five months. The mediastinum and lower extremities were treated. The factors were: 12-inch distance, 9-inch spark gap, 0.25 mm. Cu and 1 mm. Al, 100 to 150 ma.-min. The

size of the fields was not included, but a detailed table of the general areas treated was given. Doses were said to represent 50 per cent of a skin tolerance dose.

F. B. MANDEVILLE, M.D.

On the Roentgen Late Ulcers. Béla Kelen. Strahlentherapie, 1930, XXXVI, 116.

The author discusses the literature on X-ray late reactions; he has not seen one single case of idiosyncrasy among 18,000 therapeutic and 34,000 diagnostic patients. The histological findings of two roentgen ulcers are given in detail. A statistical survey of his patients, grouped according to the treatment technic, indicates that all cases treated with unfiltered roentgen rays showed telangiectasis, and several developed ulcers; 2,950 patients were treated through 3.0 mm. Al. Only in those treated over a longer period were late reactions observed, while in 1,684 cases treated with heavily filtered deep therapy radiation, not a single case of telangiectasis or late reaction has been reported so far. The best prophylaxis for avoiding late reactions is proper filtration, the producing of only mild skin reactions, and the strict observance of sufficient intervals between treatments.

ERNST A. POHLE, M.D., PH.D.

Principles of Roentgenotherapy: III.—The Biological Effect of Roentgen Rays on Normal Tissue. Ernst A. Pohle. Wis. Med. Jour., March, 1930, XXIX, 149.

Biologic effect of X-rays is dependent on absorbed energy and not on wave length. There is no proof, as yet, that the Arndt-Schultz law applies to roentgen rays, that small doses stimulate, medium doses inhibit, and large doses destroy cells. There is no selective action of X-rays on cells, the variations in effects being due to varying susceptibility of various types of tissue. Wetterer's schematic scale of susceptibility, beginning with lymphatic tissue and ending with bone, is not entirely dependable. The action of the roentgen rays on the skin, mucous membranes, blood, bone marrow, spleen and lymph glands, sex glands, glands of external secretion, thymus, suprarenals, gastro-intestinal tract, nervous system, heart and lungs, bone muscle and connective tissue, is discussed in this article, which is No. 3 of a series on the same general subject.

W. W. WATKINS, M.D.

Unusual Resistance of the Ovary to Roentgen Rays. Gustaf Blass. Strahlentherapie, 1930, XXXVI, 370.

In a girl seventeen years of age an ovarian tumor was removed; the microscopic examination showed a fast-growing carcinoma. During the following six months, X-ray deep therapy was applied to the pelvis. A total of 1,800 r was effective in the ovaries. The last treatment had been given in August; in September, the menstruation still appeared and was perfectly normal. The author reports this case because of the most unusual resistance of the ovary to irradiation.

ERNST A. POHLE, M.D., PH.D.

Roentgen Therapy of Inflammations of Glandular Organs. Carl Fried. Strahlentherapie, 1930, XXXVI, 161.

In thirty-one cases of parotitis, five of which were chronic, the results were good in 42 per cent, satisfactory in 35.5 per cent, doubtful in 9.7 per cent, negative in 6.5 per cent, and unknown in two cases. Three patients suffering from strumitis responded well. In thirty cases of mastitis, 50 per cent responded favorably, 26.7 per cent were benefited; in 13.4 per cent the effect was doubtful, and in 6.6 per cent negative. One patient did not return. In seven cases of orchitis and seven cases of epididymitis, all responded well except in one single case, while one patient could not be observed further. In individuals suffering from prostatitis not enough experience has been accumulated to warrant any statistics. While in most inflammations of the glands, 160 r may be given, 100 r to 120 r, or even less, should be considered in treating

the testicle. For parotitis and mastitis, it seems advisable to increase the dose to 200 r.

ERNST A. POHLE, M.D., PH.D.

The Treatment of Erysipelas with X-ray. Richard W. Fowlkes. South. Med. and Surg., March, 1930, XCII, 163.

This method of treating erysipelas is not new, it having been reported by Magelhaes (1914), Schmidt (1917), Hesse (1918), Schrader (1921), Hiedenhain (1926), and several others. The most notable group were those reported by Platou and Rigler of the University of Minnesota in 1926. The author reports two cases in detail, typical of the seventeen cases treated by them. The conclusion is that the effect of X-rays on the infection is generally rapid, is painless and causes no local or systemic reaction, and complications are usually avoided.

W. W. WATKINS, M.D.

Contribution to the Roentgen Treatment of Chronic Inflammatory Diseases of the Eye. Felix Jendralski. Strahlentherapie, 1930, XXXVI, 327.

In inflammation of the cornea, X-ray therapy is of value in many cases; for tuberculous processes, always. Keratitis-parenchymatiosa, particularly severe cases, respond well. In scleritis, the inflammation usually subsides quickly following irradiation, without leading to complications, while some benefit may be obtained in choroiditis and in isolated tuberculous foci. The roentgen rays were filtered through 3.0 mm. Al and one-third to one-half Sabouraud-Noiré dose was given in one sitting. Even repeated treatments did not produce an erythema.

ERNST A. POHLE, M.D., PH.D.

The Rationale of Roentgen Therapy in Infections. Fred M. Hodges. South. Med. Jour., March, 1930, XXIII, 259.

After a fairly extensive experience in the treatment with the X-ray of localized infections, the author concludes that irradiation offers more than any or all other forms of treatment in early erysipelas in adults, in furunculosis, and in subacute or chronic parotitis, with or without sinuses. Just what causes the changes produced by radiation is not known. The most likely theory seems to be that some antibody product is released by destruction of the cells, especially the lymphocytes, which increases phagocytosis. In carbuncles the X-ray gives better results than does any other form of treatment, but more accurate dosage and finer judgment are required. Slow-healing sinuses, post-operative and otherwise, are usually definitely speeded up by this treatment. In cellulitis of the neck and face, irradiation is definitely helpful.

W. W. WATKINS, M.D.

Principles of Roentgenotherapy: IV.—The Systemic Effect of Roentgen Rays. The Roentgen Reaction in Pathologic Tissue. Ernst A. Pohle. Wis. Med. Jour., April, 1930, XXIX, 207.

This is the fourth of a series of articles on the principles of roentgenotherapy. It discusses the blood composition changes following X-ray exposure and the histologic changes in the tissues. Upon the knowledge of these changes we base our conclusions regarding the effects of radiation on disease processes.

W. W. WATKINS, M.D.

Five Years' Experience with Radiotherapy in Uterine Conditions. J. S. Wilson. Jour. Arkansas Med. Soc., April, 1930, XXVI, 215.

The author has treated approximately 120 cases of uterine conditions by radiotherapy since 1923, and reports on the first 100 of these. Of these, 26 were functional menorrhagia or metrorrhagia, and were treated by intra-uterine radium 1,200 to 2,400 mg.-hrs., with one hour of X-ray over each ovary. Radium was filtered through 0.5 mm. silver and 2 mm. brass covered with rubber: X-ray at 135 K.V., 10 inch distance, 0.5 mm. Cu and

0.5 mm. Al filter. Results were all satisfactory. Twelve cases of fibroids were given the same dosage with good results. Sixty-two were malignancies, in which from 4,000 to 7,200 mg.-hrs. of radium plus four hours of external radiation by X-ray was the rule. Only two patients have passed the five-year period, though it is expected that several of the others will. Only fourteen have died.

W. W. WATKINS, M.D.

SINUSES (DIAGNOSIS)

Accessory Sinus Disease in Children. I. R. Vaile. Can. Med. Assn. Jour., February, 1930, XXII, 198.

The symptom group of this condition comprises constant "head colds," profuse nasal discharge, mouth breathing, frequently running ears, and periodical attacks of sore throat.

The X-ray findings are: clouding of both antra in all cases, and polypoid change and thickening of mucous membrane in some. No involvement of the frontal or sphenoid sinuses, and few of ethmoiditis were found in the author's group of cases. No evidence of empyema of the antrum was found.

Antroscopic examination with the Spielberg antroscope showed thickening and congestion of the mucous membrane, and occasionally small and large polypi.

Two types of treatment were followed: palliative and surgical. Palliative treatment was tried in every case, which consisted of daily suction, spraying with 10 per cent argyrol, and exposure to radiant heat. This cured 80 per cent of the cases. If palliative treatment failed, surgical measures were employed. These consisted in puncturing the antrum and irrigation with normal saline, sometimes followed with 2 per cent mercurochrome. This irrigation should be kept up for six weeks or more.

L. J. CARTER, M.D.

Roentgenology of the Accessory Nasal Sinuses. Dorwin L. Palmer. Am. Jour. Surg., March, 1930, VIII, 657.

In this article the author describes the Rhiese technic. This is taken with the sagittal plane of the skull at an angle of 23 degrees and with the head turned in the oblique position on either side, thus throwing the sphenoid and ethmoid labyrinths over the orbit on the side being examined. Both sides should be done stereoscopically. He believes that this technic is the most valuable for the routine study of the sphenoids and ethmoids, and that films made in the Waters position give dependable information regarding the maxillary antra and the frontal cells.

He believes that only when the otolaryngologist and the roentgenologist study the cases together, with careful attention to the surgical findings compared with the roentgen picture, can the greatest benefit be derived.

H. P. DOUB, M.D.



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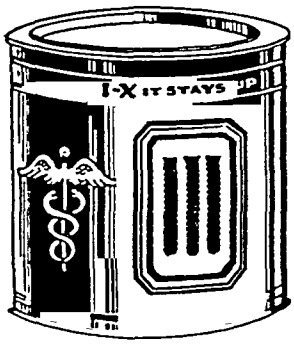
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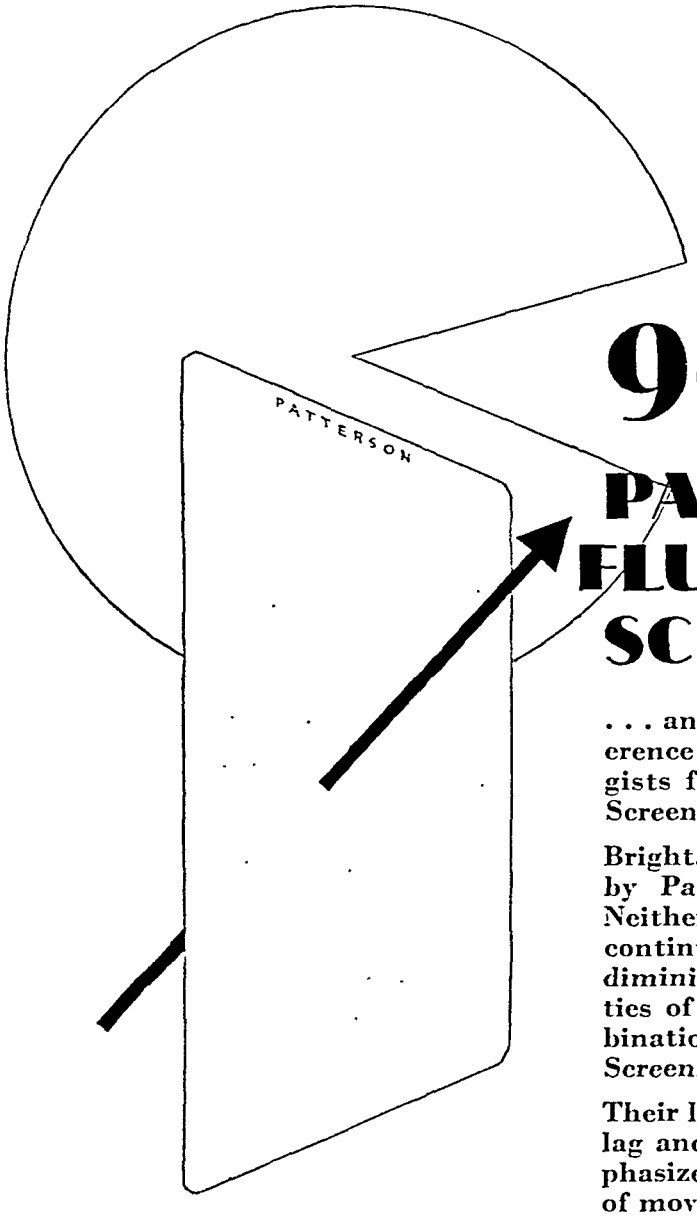
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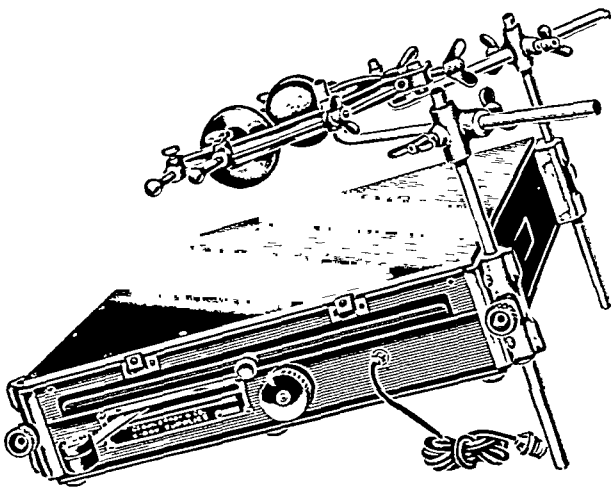
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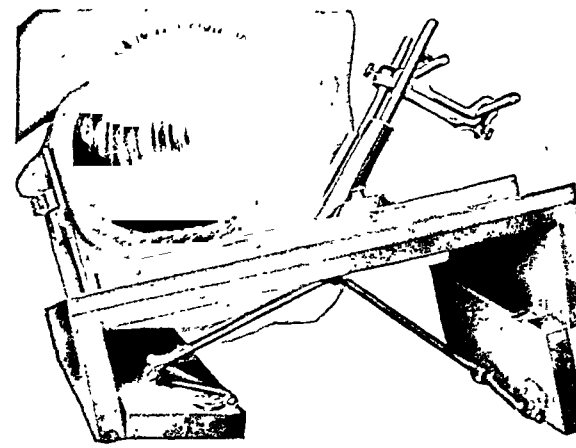
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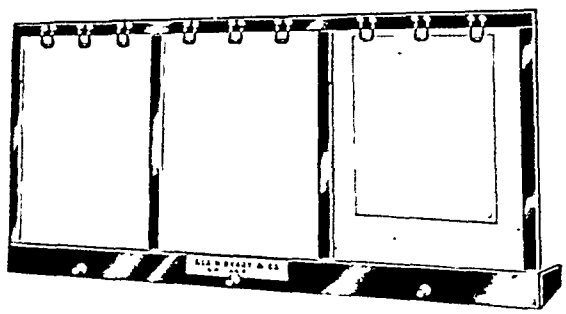
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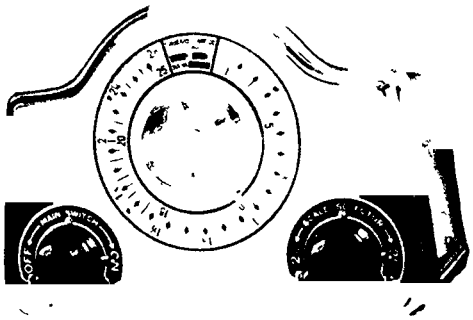
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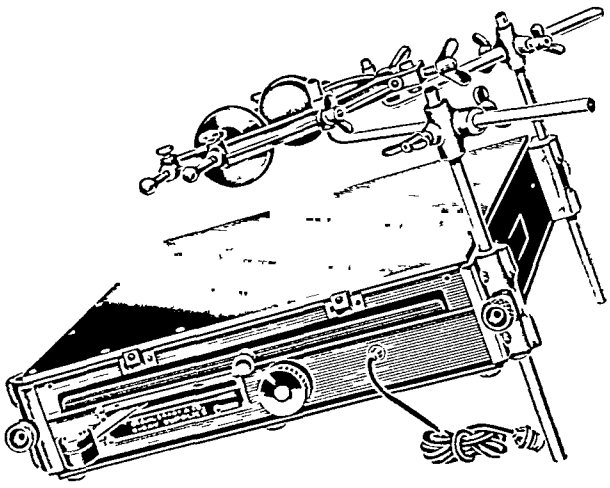
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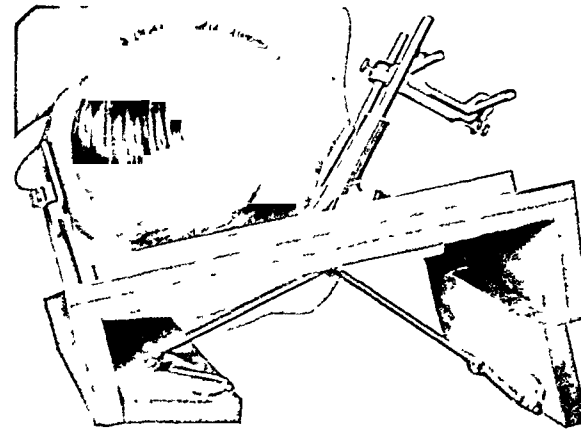
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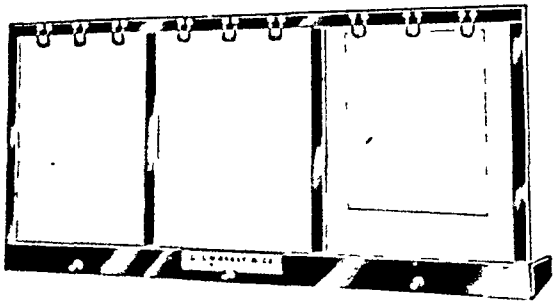
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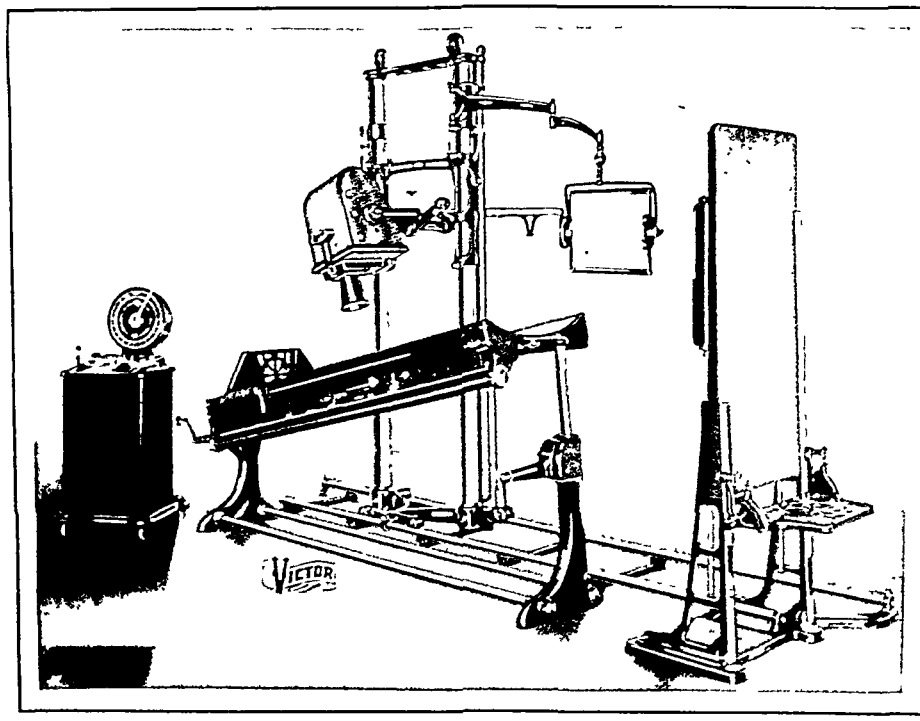
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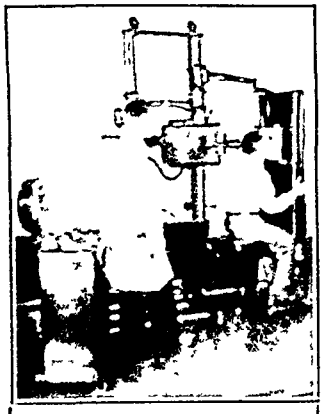
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A MONTHLY JOURNAL DEVOTED TO CLINICAL RADIOLOGY AND ALLIED SCIENCES

PUBLISHED BY THE RADIOLOGICAL SOCIETY OF NORTH AMERICA

VOL. XIV MARCH, 1930 No. 3

FOREWORD

In view of the fact that cancer is holding the center of the American medical stage to-day, it seems fitting that our Journal, RADIOLOGY, should appear in a special edition limited to the subject *cancer*. The Radiological Society of North America, realizing the importance of this study, has featured a Cancer Symposium at each of its annual meetings, and this present issue contains, therefore, the papers on this subject which were presented before this Society at the Toronto meeting just concluded. The writer feels that, inasmuch as the contents of this issue represent broadly scientific facts pertaining to the incidence, pathology, diagnosis, and treatment of cancer, the cancer student may find within its pages sufficient material of interest to warrant its careful perusal.

It must be admitted that research into the science of radiology has been instrumental in bringing the cancer problem up to its present point of activation. Then, who can deny the possibility that by these selfsame endeavors the whole mysterious cancer problem may be solved through this very research, which is being so splendidly supported by the type of men who contribute these papers?

The officers of the Radiological Society of North America, who have authorized the publication of this special issue, and the Editor of RADIOLOGY, sincerely trust that all the members of the Society and the subscribers to the Journal will appreciate the effort made in the preparation of this issue and will approve of its contents.

ALBERT SOILAND, M.D.,
Chairman, Cancer Symposium.

FACTORS DETERMINING RADIORESISTANCE IN TUMORS[1]

By JAMES EWING, M.D., Pathologist to Memorial Hospital, New York

THE factors determining radioresistance in tumors are very numerous. They consist mainly in structural components of the tumor but arise as the result of many complicating conditions that occur in the course of tumor growth. A general conception of the subject may perhaps best be obtained by a review of various tumors and an inquiry into the nature of the resistance in each. Consideration of what may be accomplished by radiation in each of these groups may also be attempted.

(1) *Resistance due to adult character of stroma.*—This form of resistance is observed in many types of sarcoma, osteogenic, neurogenic, chondrosarcoma.

The stroma of many osteogenic sarcomas consists of bone, osteoid tissue, hyaline material, fibrous tissue, and often cartilage. All of these structures resist radiation and cannot be absorbed. There is a very great variety of such tumors so that the exact fate of any one of them under radiation is difficult to predict, but in general they do not diminish in size under treatment. Their nutrition, however, is much affected, and pronounced regressive changes may be produced with the deposit of calcific material, liquefaction with cyst formation, and hyaline fibrosis. The attempt to secure extreme regression generally leads to painful radiation osteitis and spontaneous fracture. The best results seem to be obtained by repeated, full, but not excessive doses, aiming at growth restraint. That such efforts may be worth while seems to be shown by the following cases.

Case 1. *Osteogenic sarcoma of lower end of femur in a girl 18 years of age.*—Devitalization of a cellular bone tumor without reduction in size. Thirteen X-ray treatments, high voltage, over a period of two years. Spontaneous fracture. Amputation two and one-half years after onset. No metastases. Well eight years.

Examination of the tumor revealed that the growth, 12 x 14 cm. in diameter, had been liquefied in the central portions, while a thick shell of osteoid and fibrous tissue remained. Sections showed stainable tumor cells, without evidence of growth activity. The tumor had been largely devitalized, without reduction in size. The fact that no metastases had occurred in two and one-half years, we are inclined to refer to the effects of radiation. We now have records of several similar cases in which the usual metastases of osteogenic sarcoma failed to occur after radiation, although the limb had to be amputated.

Case 2. *Medullary fibrosarcoma of femur in a female subject, 33 years old.*—Cessation of growth after prolonged radiation. Fibrous union. Amputation after three years.

Examination of the tumor revealed a very firm mass of fibrous tumor tissues replacing the lower four inches of the femoral shaft. The structure of the original tumor showed a highly resistant fibrosarcoma, with much fibrous stroma and large spindle tumor cells. In the amputated tumor the cells were very scanty, and the stroma hyaline. The tumor had been devitalized. The patient has been well for eight years. The absence of metastases was to be expected from the fibrous character of the tumor. The radiation therefore accomplished nothing of value to this patient.

Chondromas and chondrosarcomas are resistant to radiation, but growth may be restrained, central softening may occur, and local extensions and metastases may be prevented.

Case 3. *Bulky chondroma of the os calcis in a boy 4 years old.*—Persistent radiation caused cessation of growth and progressive calcification of the tumor. At

[1]Read before the Radiological Society of North America at the Fifteenth Annual Meeting, at Toronto, Dec. 2-6, 1929.

the end of four years the tumor was slightly reduced in size, but the natural growth of the foot made the disproportion in size between heel and foot so slight that the child now has normal use of the latter.

Neurofibromas and the more cellular tumors verging toward neurosarcoma are generally quite resistant because of their dense stroma. Yet, in many instances persistant radiation with moderate doses may restrain growth and prevent the natural evolution of the tumor. There are two advantages in the radiation treatment of resistant neurofibromas: First, many of the tumors recur after operation, and in more cellular aggressive form; second, many of the tumors of the subcutaneous nerves are multiple, and the multiple tumors arise at successive periods, so that operation is often followed by the development of a new tumor in the same nerve trunk. Radiation, extending over a wide area of the affected nerve trunk, tends to prevent the appearance of new tumors. As neurofibromas become more cellular and therefore more malignant and more certain to recur after operation, they become less radioresistant. Hence, the effort to control them by carefully planned radiation is desirable and often successful.

As an exception to the rule that highly fibrous adult tumors are resistant, we have the example of the keloid, which responds slowly to full dosage, probably because the nutrition is dependent upon many fine lymph spaces which are obliterated by radiation.

(2) *The adult characters of epithelial cells and the substantial blood supply render adenomas and papillomas radioresistant.* Adenomas of breast and thyroid gland, and papillomas of skin, mucous membranes, and larynx, fail to respond, as a rule, to rather full dosage. I do not find a report of any systematic effort to determine what may be accomplished by small repeated doses and a long period of observation in the treatment of such tumors. Papillomas of the bladder generally require interstitial radiation of the pedicle, which cuts off the blood supply.

As an exception to the rule with adult tumors, myoma uteri responds to radiation, with widespread liquefaction and absorption of the relatively adult muscle cells. Here again, it seems probable that interference with blood supply plays an important part.

(3) *Carcinomas are resistant in inverse proportion to the degree of anaplasia and in direct proportion to the amount of desmaplastic reaction which they excite.* Many carcinomas are really disseminating infiltrating adenomas in which the anaplasia is only slightly greater than in adenomas. This group includes adenoma malignum and many alveolar carcinomas. As the anaplasia increases, the resistance diminishes. There are so many and such wide differences in the degree of anaplasia of carcinomas, that the attempt to grade them according to radiosensitivity is justified. Indeed, this investigation often succeeds in explaining the variable results of radiation and serves as a valuable guide in the plan of treatment. I believe that with increasing experience the grading of tumors from this standpoint will become much more accurate and reliable than it is at present possible to make it, and I have little sympathy with those who would dismiss the subject as impracticable. Such studies call for a very careful analysis of the structure, nutrition, and physiology of tumors, all of which themes lead to increased knowledge of the nature of the diseases with which we have to deal.

(4) *In mixed tumors in which one element is sensitive and the other resistant, the malignant portion may be sterilized, although the tumor does not diminish in size and a false impression of radioresistance may be gained.* This situation arises with mixed embryonal and adult tumors of the testis. The embryonal carcinomatous ele-

ments are sensitive and usually yield to moderate dosage, but the adult areas of cartilage, fibromuscular tissue, gland remnants, and epithelial cysts do not shrink, and the tumor remains unaltered in size, although deprived of its growth capacity. Comparative radioresistance is also observed with many adenocarcinomas of the testis. An occasional source of spurious resistance arises when hemorrhage occurs in a very vascular tumor, converting it into a hematoma. This event was demonstrated in a recent case of very vascular carcinoma of the testis.

Many other teratomatous tumors in other situations, as abdomen, kidney, and sacral region, exhibit the same complex structure and the same spurious resistance to radiation.

(5) *A special case of spurious resistance is observed, with very vascular giant-cell tumors, which are well designated as benign bone aneurysms.*

Case 4. Female, 35 years of age. Presented a multicystic tumor of the lower end of the femur which was diagnosed as a giant-cell tumor. Radiation treatment was instituted with the usual moderate doses, but the tumor continued to increase in size quite rapidly so that the suspicion of a malignant character was gained. After reaching very large dimensions, the limb was amputated. Examination revealed a large multicystic tumor with free arterial connections, the cysts being filled with blood. Sections showed that the tumor tissue had been largely devitalized, but the weakened capsule was unable to withstand the intermittent pressure of the blood stream and extensive dilatation occurred in a devitalized benign tumor. Other cases of the same type have been observed.

(6) *The nature of the tumor bed has much influence on the response to radiation, both favoring and in other cases retarding the response to treatment.* The high resistance of malignant tumors invading bone or cartilage is well known. In fat tissue also carcinomatous cell groups generally resist radiation and require caustic doses for control. I believe that this influence of fat tissue is one of the main reasons why mammary cancer shows such high relative radioresistance. The fat tissue does not permit easy access of blood, leukocytes, and plasma cells, and granulation tissue will not develop in it unless there has been necrosis of fat, and this requires caustic doses. These observations are difficult of explanation by those who hold that the regression of tumors is due solely to the destructive effect of the rays upon the tumor cells.

(7) *It is well known that infected tumors which are the seat of exudative inflammation do not react well to treatment, but a full explanation of this fact is difficult to find.* About foci of polynuclear leukocytes in infected tumors I sometimes find very numerous mitoses. It is said that leukocytes furnish growth-stimulating substances to tumor cells in culture. The infection loosens the surrounding tissues and permits infiltration by invading tumor cells, which more readily penetrate tissue spaces, vessels, and lymphatics. Radiation also tends to accelerate the inflammatory process. Yet the high circulation and metabolism of infected tumors should render them more sensitive to radiation. The poor results of treating infected tumors indicate that a suitable environment of the tumor is an essential factor in bringing about regression.

(8) *Acquired resistance.*—The increased resistance acquired by tumor cells which have been subjected to repeated inadequate dosage is one of the most remarkable phenomena brought to light by radiation therapy. The same relation has been observed for normal cells by Holthusen, who found that a dose much larger than an epilation dose was required to restrain the regenerat-

ing growth of hair in an epilated area of scalp. Acquired resistance of tumor cells is best illustrated in the cases of long-radiated tumors which recur in dense scar tissue. This condition may be called "abortive fibrosis." Here the tumor cells are protected against the attack by leukocytes and granulation tissue, and their metabolism is probably very low. Yet, the resistance may become so high that doses approaching the caustic type injure the stroma and the normal tissues, while the tumor cells survive. It appears that some tumor cells enjoy a capacity for adaptation to the effects of rays. Later they may exhibit very active growth, which we are inclined to refer to the loss of growth restraint in the over-radiated tissues and body. This theory must necessarily have a bearing on the plan of radiation therapy. The exact conditions under which it occurs require careful study. It does not seem to interfere with the successful results of moderate doses delivered over a long period in comparatively resistant tumors. It seems to be a sufficient basis for preferring to deliver the necessary dose as quickly as possible, especially when the total dosage required is high.

(9) *The natural history of tumors as a guide to radiation therapy.*—In planning the treatment of any resistant tumor, it is highly important to keep in mind the natural history of the tumor. We seldom see the natural history of most tumors, owing to interference in their early stages. It is a nearly universal assumption that all tumors possess unlimited powers of growth and that unless they are dealt with summarily they will continue to grow indefinitely. This assumption is not justified.

Many chondromas cease to grow after the bones have reached their normal full development. Many fibrosarcomas of bone enjoy only a very slow growth, continuing over many years without metastases. The natural history of the more aggressive giant-cell tumors of bone ends in death by hemorrhage and infection, but the less aggressive forms often cease to grow and spontaneously regress, sometimes after fracture. Under the present standard surgical treatment of mixed tumors of the salivary glands, these tumors have a rather high mortality rate from recurrence and local extensions, while in many others there is permanent deformity from loss of the facial nerve. Yet many salivary gland tumors have a limited growth capacity. Some of them cease growing after reaching a moderate size and remain stationary for as long as twenty-five years. This rule does not apply to the cellular carcinomas of the salivary glands.

Most subcutaneous neurofibromas remain indolent throughout life; some grow to moderate dimensions over a very long period, but give little disturbance to the patient, while others become pedunculated and may even be spontaneously extruded.

A considerable proportion of uterine myomas become cystic or fibrous or calcified. There is little opportunity to observe the natural tendencies of adenofibromas of the breast or of low grade adenomas of the thyroid gland, but there are old records of many of these tumors which show that they may cease growing after a variable period. The great majority of pigmented moles become fibrous, papillary, or pedunculated and remain harmless throughout life.

Even with frankly malignant tumors, it is well known that when they are not tampered with, the course may be very slow and continue for five, ten, or even twenty-five years without grave disturbance to the patient. Moreover, it is a well attested fact that incomplete removal of such tumors is often followed by recurrence in more malignant form.

When, therefore, one approaches the treatment of such tumors with the idea of complete surgical removal, or with the object of killing tumor cells with heavy radia-

tion, it should be remembered that while this object may be attained, yet if it fails the condition of the patient is generally rendered worse rather than better and that many benign are converted into malignant growths.

From this point of view, there would seem to be a large field for radiation treatment of benign tumors of uncertain prognosis with the object of restraining growth, limiting the size which the tumor may reach, preventing complications, rendering the condition practically harmless, but not attempting to cure the tumor in the radical sense. While this plan is not in accord with the modern tendency to secure quick and final results, very numerous cases can be cited to illustrate its great advantages to the patient.

When one radiates low grade neurosarcoma and then becomes impatient at the end of a few weeks or months because there is no result, and operates, he is not pursuing an intelligent plan. It has recently appeared that patience and persistence accomplish much more for these very dangerous and distressing conditions than formerly seemed possible.

Mixed salivary gland tumors often fail to show immediate response to radiation, but if one can reduce the growth capacity of these tumors by from 10 to 20 per cent, the final result after one year or more may be a harmless, quiescent, although persistent mass, which is far better than the loss of the facial nerve, and death from a recurrent infiltrating ulcerating tumor.

One of the first cases of recurrent spindle-cell periosteal sarcoma that I saw treated by radiation continued to grow for four months after heavy radiation, which had to be suspended. It stopped growing at six months, was regressing at one year, and then completely disappeared, never to recur.

I have been much interested in a case of huge lymphangioma of the tongue in a child one year of age, in which the tongue formed a large protruding ulcerating mass with an apparently hopeless prognosis. Persistent radiation gradually stopped the growth, while the natural increase in dimensions of the child's head and jaws eventually permitted the tongue to recede within the mouth, so that the child now, at the age of six years, is an extremely vigorous, healthy youngster. The only recorded cures of juvenile myxosarcoma of the nares and pharynx have been accomplished by long continued, persistent use of small doses of radium or X-rays, but the aggressive attack on these tumors by surgery or interstitial radiation invariably results in disaster.

The exact mechanism by which prolonged radiation affects the growth of resistant tumors is a matter requiring more careful investigation than it has received. There are probably several factors concerned, but it seems to me highly probable that the influence is mainly upon the blood vessels, which eventually shrink and cut off the blood supply. If the mechanism were more fully understood, it might be possible to plan the treatment more intelligently and to vary the dose so as to accomplish different effects in different tumors.

It is a well established principle, supported by clinical observation and experiment, that radiation invariably reduces growth capacity of cells and tissues, although months or years may elapse before its final effects become apparent. Based upon this principle, always controlled by sound clinical judgment and influenced by the natural history of the disease, efforts to control resistant tumors by radiation may well be pursued with the hope of enlarging the scope of successful radiation therapy.

TREATMENT OF MALIGNANT GROWTHS OF THE NASAL ACCESSORY SINUSES AND NASOPHARYNX[1]

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IT is not the purpose of this discussion to present a detailed review of all phases of treatment of tumors of the accessory sinuses and nasopharynx but rather to call attention to a few of the more outstanding factors in treatment. For the most part, attention will be directed only to the malignant growths in these locations.

Probably no location in the body presents so many complicating factors as are to be found centered immediately about the nasal passages. A wide range of tumor type is possible. The primary site or origin of growth is often difficult and frequently impossible to determine; bone and cartilage involvement is hard to define; interference with sinus drainage and infection give rise to inflammatory tissue which it is often impossible to differentiate clinically from tumor tissue. The peculiar anatomy of the paranasal sinuses favors inflammatory processes. How much this contributes as a predisposing cause in the development of many of the growths is, of course, not known: certainly it is an important factor. Inflammatory processes alter the normal type of tumor growth and influence unfavorably the protective cellular reactions in the surrounding normal tissue.

Mixed infection, with the resulting inflammatory processes, complicates diagnosis. It adds to the surgical risk and aggravates tumor growth. Osteomyelitis almost invariably accompanies tumor invasion of bone, interfering with the reaction to the physical agents of normal tissues about the growth. More patients with these involvements succumb to fatal infection than do those subject to the natural progress of the disease.

HISTOLOGY

The complex embryology of the parts under discussion affords opportunity of tumor origin from many developmental anomalies; hence a wide range of tumor type is met with. In his book on "Neoplastic Diseases," Dr. Ewing has enumerated thirty-seven varieties of growths found in or about the nasal passages, any one of which is capable of blocking them.

A great many of the growths falling in this general group are intimately associated with the maxillary antrum. Whether most of the tumors referred to as antrum growths are primary or are secondary extensions from other sinuses or the nasal passages is frequently not understood. Inflammatory processes often mask the true picture.

In our own experience, these cases are usually so far advanced that the exact site of origin cannot be determined with any degree of accuracy. In a group of 136 malignant growths of the antrum examined in our service between 1917 and 1929, 83 per cent were so far advanced as to be inoperable by radical excision of the superior maxilla. Under such circumstances of advanced growth it is obviously impossible to determine with any degree of accuracy what the actual primary site of growth was.

Carcinoma is the predominating type of tumor. A cylindrical cell carcinoma of adenocarcinomatous structure is most common in all of the sinuses. It is rapid in growth, bulky, and bleeds easily. It invades bone readily or may erode it from pressure. Consequently, with this type of tumor in both

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antrum and nasal passage it is impossible to determine the primary origin.

Squamous-cell carcinoma usually represents secondary invasion of the antrum, but may arise there primarily from lining membrane cells altered or flattened by some previous inflammatory process. In our series of cases just referred to, 39 per cent were of squamous-cell structure.

There are certain basal-cell structures, adenoid cystic epithelioma, cylindroma, or endothelioma, which are altogether less malignant and of slower growth than other types but are not usually recognized until late. Of our series, 7.4 per cent were of adenoid cystic basal-cell structure. Strangely enough, we have had a similar percentage of transitional cell carcinomas in the antrum. From the normal histology of the parts, one would scarcely expect growths of this type to be so frequent as far forward as the maxillary antrum.

Most of the so-called "sarcomas" of the antrum are in reality round-cell carcinomas of atypical structure, the result of chronic inflammatory changes in the lining mucous membrane. True sarcoma of the antrum and nares is angiosarcoma or myxosarcoma. Osteogenic sarcoma is rare, yet does occur and is usually easily recognizable radiographically. In our entire group of antrum cases, only 10 per cent were found to be sarcomas.

Mixed-, spindle-, and round-cell sarcomas of the turbinates, so called "fibrosarcomas," are not uncommon. Chondromyxosarcoma of the vault of the pharynx is met with occasionally in children.

These two last mentioned types of tumor are usually of slow growth and of a low grade of malignancy and hence are amenable in a high percentage of cases to direct surgical treatment, providing it is very thoroughly done. They do tend, however, to recur, with the usual persistence of a slow, adult type of growth, and terminate fatally more often than is usually visualized, through the associated infection which is frequently attendant upon such a process.

Lymphosarcoma may appear at almost any point in the paranasal sinuses but is practically always only a part of a more generalized disease. It is not improbable, however, that this disease frequently has its origin in the lymphoid tissue of the postnasal space. Its invasion of the sinuses, therefore, is from behind forward. Its rate of growth is usually so rapid that the exact origin can only be guessed at in the nasopharynx. It has been our experience that lymphosarcoma is second in frequency only to the transitional cell carcinoma which occurs in the lymphoid tissue adjacent to the fossa of Rosenmueller.

DIAGNOSIS

The symptoms and clinical course of the malignant diseases of the paranasal sinuses are too well known to merit discussion here except for emphasis on one point. The cases are almost invariably far advanced before a definite diagnosis is made. Speaking generally, the only symptoms which seem to arouse the consideration of newgrowth are those incident to the late stages of the disease, namely, nasal obstruction, with nasal discharge or persistent bleeding, or pressure symptoms, with gross destruction of bone. Mention has already been made of the fact that of 136 cases of newgrowths of the antrum, 83 per cent were so far advanced upon coming to us as to be inoperable even by total excision of the superior maxilla.

The more inaccessible the primary growth is to routine examination—and particularly the smaller the growth is—the later it is recognized. This is well illustrated by our experience with transitional cell carcinoma primary in the nasopharynx. This type of growth is characterized in most instances by a very small, and, for a time, slow growing,

frequently symptomless, primary growth. In our experience, it is the predominating growth in the vault of the nasopharynx and it is interesting to note that, of all of our nasopharyngeal growths, 73 per cent of cases showed metastatic involvement of cervical lymph nodes at the time of applying to us for treatment. In other words, the metastatic extensions to the disease were the first to call attention to the presence of newgrowth. It does seem that many of these processes are regarded as of inflammatory origin for too long a period, and that biopsy or earlier surgical exploration of more sinuses, keeping in mind always the possibility of newgrowth, would result in a saving of many of these cases. It is my impression that many of the preliminary operations done in and about the nasal passages in the presence of chronic inflammatory symptoms are rather poorly planned from a strictly surgical standpoint, and that in too many of them histological examination of tissue removed is ignored.

In our series of antrum cases, 59 per cent had a prolonged course of nose and throat treatment before definite diagnosis of newgrowth was made, and 45 per cent of them had had various local operations on the nasal passages which did not reveal the true character of the disease. The same was true in 44 per cent of our nasopharyngeal growths.

It has been our unfortunate experience that radiographs for diagnostic purposes have not been as valuable as one might ordinarily expect. They may lend a certain amount of influence one way or the other, but are usually not conclusive in differentiating between a strictly inflammatory process and newgrowth, except in the very late stages of the disease, where the differentiation is obvious to other and simpler means of examination. It is true that we have been dealing almost entirely with well-advanced and late stages of malignant disease, yet within this group, where determination of extent of growth is of considerable importance, we feel that diagnostic X-rays have been of real value to us in only about 5 per cent of the cases.

SURGICAL OPERABILITY

A review of the literature reveals rather few favorable results in the treatment of adult types of malignant growths in the sinuses. This is not surprising, for we realize that surgical principles as applied elsewhere can rarely be applied in the treatment of accessory sinus growths, except, perhaps, in excision of the upper jaw for early growths in the maxillary antrum without extensive bone invasion. Where the technical surgical approach to an adult type of malignant growth is either through or immediately adjacent to the tumor-bearing area, little can reasonably be hoped for by such a removal, and, unfortunately, this is almost invariably the case in operating about the nasal passages. The procedures in general represent little more than a modified curettage, and, since the exposure is frequently inadequate and the field often obscured by bleeding, the curettage is more apt than not to be incomplete. No wonder that the disease recurs so promptly.

From a serious and strictly general surgical viewpoint, therefore, malignant growths in and about the paranasal sinuses are all surgically inoperable unless a degree of mutilation is accepted, which, in almost every instance, would not be tolerated—at least until the disease had extended beyond the bounds of operability even by these means. It is probable that the palliative benefits of the average intranasal operation are due to the factor of drainage and that the actual removal of tumor tissue is only secondary. From a curative standpoint, therefore, operative surgery has rather little to offer.

The same anatomical hazards which defeat operative surgery in the treatment of this group of diseases are equally serious as stumbling blocks to successful treatment by irradiation. Unless a sufficient quantity of a proper type of radiation can be delivered accurately and uniformly to the tumor-bearing area, and unless the reaction to this treatment can go forward with a minimum of inflammatory complication, it is useless to employ irradiation with any hope of curative results.

It is here that the combination of surgery and radiation offers a possibility for dealing with a varied group of malignant diseases in complicated anatomical locations. It is possible to gain access to and to provide drainage from practically all of the locations under discussion by reasonable and relatively simple surgical procedures. Usually these can be carried out without disfigurement to the patient. Beyond that, the problem in most instances becomes one of proper technical application of the irradiation.

It is this principle of combining radiation for the treatment of the tumor-bearing area and surgical measures for access and drainage that we have attempted to follow in our work for the past several years. There has been gradual improvement in our various surgical methods of access, and, particularly with more accurate data on radium dosage and technical means of application, we feel that a reasonable hope is held out in a very considerable number of these cases which previously could be regarded only as palliative prospects at best.

DOSAGE

During the past year, a tremendous advance in the direction of dosage accuracy has been made through the efforts of my associates, Dr. Martin and Dr. Quimby. Their work is published in detail elsewhere so that only brief reference need be made of it here. They have calculated the actual intensity of dosage in a large series of successfully treated cases and have found that, for the more adult types of epithelial tumors, a dosage intensity ranging somewhere between seven and ten erythemas is apparently necessary for successful eradication of the disease. This, of course, is a very broad statement and requires qualification from numerous angles.

The next step was obviously the application of this to the treatment of cases, with the result that for a given case the dosage intensity was determined upon, and then, from the physical standpoint, the actual applicator dose or combination of applicator doses predicated upon a practical basis to provide the total dosage actually indicated.

Naturally, many factors enter into the decision of the dosage intensity for any given case. The more adult types of growth call for greater intensities; the more embryonal types, being more radiosensitive, require less.

The location of the growth has a great deal to do with determining, from the physical standpoint, the source of radiation and the type of applicator to be employed. As has been shown by Martin and Quimby, external radiation about the head and neck, whether X-rays, heavily filtered radium at distance, or a combination of both, affords at best only about 200 per cent of an erythema in the various locations in which it is necessary to deal with primary growths. In certain locations it is even difficult to attain this degree of intensity by external applications only. In certain palliative procedures this may, of course, be all that is desired, but where permanent control of the disease is the objective, some other means of increasing the intensity of irradiation within the tumor-bearing area must be sought. This may be through the use of filtered radium emanation in gold capillary tubes, by heavily filtered tubes in rubber, or

by having a large quantity of emanation in a small heavily filtered sphere.

In deciding upon dosage in this manner, it is the responsibility of the Physical Department to select whatever type of radium or radon container is most practical to increase the intensity of radiation to the proper degree. We are rapidly approaching the point where responsibility for determining the combination of technical or applicator doses or, if you like, radiological prescription writing, is passing out of the hands of the clinician and is being added to the responsibility of the physicist co-operating in this work.

So far we have attempted, in all except strictly palliative cases, to deliver the total dose of irradiation within a period of four weeks. This means that where radon by implantation is employed following external irradiation, the external applications must be completed in the first fortnight so that the radon implantation can be made at the end of that time, since it is active for approximately a fortnight after implantation.

It is frequently possible to take advantage of a tumor-bearing area as a radium applicator, so adjusting the dose that surgical removal to provide more adequate drainage will be done as soon as the emanation has decayed. In case it is more desirable to provide the drainage at an earlier date, the initial dose of radon implanted can be increased and then cut short by the surgical removal before it has completely exhausted itself.

Post-operative irradiation in such a combination of surgery and irradiation is not, in our judgment, as desirable as pre-operative. In certain instances, however, it becomes obligatory. It is frequently not possible to implant radon with reasonable accuracy in certain of these growths without some preliminary surgical exposure. This is well illustrated in many of the growths primary in the antrum, which have invaded bone extensively and are extending in the direction of the orbit or ethmoids. Here, surgical cleaning out to facilitate drainage and at the same time to permit of access to the more inaccessible portions of the growth is essential, and is combined with immediate application of heavily filtered radium in some type of suitable heavily filtered applicator or, if the anatomical relationships are suitable, by radon implantation.

TREATMENT OF CERVICAL METASTASES

So far, we have considered in a general way only the treatment of the primary growths in this group of diseases. With many of them, however, treatment of the secondary extensions, particularly to cervical lymph nodes, is equally or more important than treatment of the primary tumor. For these we follow the same general principles as have been outlined previously for metastatic nodes secondary to intra-oral carcinoma—that is, a combination of X-rays, radium, and surgery.

All necks, in cases of metastasizing malignant growths of the paranasal sinuses and nasopharynx, are radiated with short wave length X-rays. If no nodes are palpable, the cases are kept under careful, periodic, routine examination. If an enlarged movable node with presumably intact capsule is present on admission or appears later, *in cases of epidermoid carcinoma,* the X-radiation is supplemented by radium packs, and, following this, a unilateral dissection is done under local anesthesia. Radium emanation is usually buried in the wound at the time of the surgical dissection. If the metastatic node has perforated its capsule and the infiltrating growth is fixed in adjacent structures, we class the case as inoperable. External irradiation is continued and emanation tubes implanted in the mass as a palliative procedure, but no dissection is

attempted. Likewise, if the primary growth is far advanced but with an otherwise operable neck, we treat the neck as well as the primary mass in a purely palliative manner. If the primary growth in the sinus is of basal-cell type, no attention to the neck is necessary because the tumor does not metastasize. If the primary growth be a lymphosarcoma, no surgery is indicated in the neck. It is a disease which extends widely and rapidly, and, as for any single local manifestation, it can always be managed better by the physical agents than by surgery.

As for the true sarcomas occasionally met with in the sinuses, I am of the opinion that no surgery is indicated when metastases are present. They are too apt to be multiple and had best be treated by radiation.

One group of the embryonal epidermoids should receive special mention in connection with their cervical metastases, namely, the transitional cell carcinomas. Their response to irradiation is more like that of the lymphosarcomas than of the adult epidermoids. External irradiation, or this plus radon implantation, is all that is indicated by way of treatment. This type of disease is apt to metastasize widely and to distant parts, so that in our judgment neck dissection has not the same prospect of permanent benefit that it has in the true acanthomas. Furthermore, the transitional cell carcinomas are locally quite radiosensitive and hence lend themselves, particularly as far as local or individual masses are concerned, to successful treatment by irradiation.

It is, of course, extremely difficult to appraise this plan of neck treatment, even though we have been following it now for several years. It is encouraging, however, to note that in our series of antrum cases 63 per cent had no nodes throughout their entire course, while only 16 per cent developed nodes after admission to the service. It would seem that the routine precautionary radiation had some influence in the direction of growth-restraint to palpably uninvolved necks.

CONCLUSIONS

1. Surgical exploration of the paranasal sinuses and biopsy should be resorted to earlier and more frequently, so that earlier diagnosis of newgrowths may be made.

2. With few exceptions, the principles applying to surgical removal of cancer in general cannot be carried out in dealing with growths in the paranasal sinuses.

3. Radium and X-rays are of value in treating this group of cases, but, except in palliative procedures, must be used in conjunction with surgery.

4. Radium and X-rays may be depended upon to eradicate the tumor tissue if applied accurately and uniformly throughout the growth in sufficient dosage.

5. Surgery must be employed to provide exposure for radium application and adequate drainage.

6. The anatomical relations of the parts are such that infection is a much greater menace here than in newgrowths in most other locations.

RADIATION TECHNIC FOR CANCER OF THE MOUTH WITH COMBINATIONS OF GAMMA RADIUM RAYS AND VARYING QUALITIES OF HIGH VOLTAGE ROENTGEN RAYS[1]

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TECHNICAL methods of radiation and dosage must be developed as carefully as the details of a difficult operation. Unless treatment is planned so that all parts of a cancer-bearing area receive a uniform distribution of radiation, with intensities sufficient to destroy cancer cells, then any radiation procedure is fundamentally inadequate to cope with the disease, and the case will not get the benefit of any virtue which efficient radiation may otherwise hold out for the particular histological character of a given growth.

The value of roentgen ray and radium in the treatment of early cancers, particularly early cancers of the skin and mouth, and more particularly the early epidermoid cancers of the cervix, is incontestible: even some very advanced cancers have shown remarkable regression. These improvements are increasing in number with progress in technic, together with a more general enthusiasm and systematic clinical application of established physical principles, and the free communication of experiences between institutions throughout the world.

While cancer of the esophagus and gastro-intestinal tract, hypernephroma, and brain tumors have been particularly refractory to radiation, the value and limitations for good in advanced cancer, particularly of the skin and intra-oral and pelvic lesions, are fully recognized.

The fact that early cancers have responded to a manifold variety of technics has long been recognized as evidence of a difference in the sensitivity of different types to radiation. The marked variation in the cellular structure of epidermoid carcinomas led to Broders' (2) investigation, with grading of tumors into four groups according to the degree of cellular differentiation. Later, Healy and Cutler (7) brought out the striking paradox that with radiation treatment the prognosis is better with the higher grades of malignancy, because the radiosensitivity increases with the malignancy.

Ewing's (4) observations on the radiosensitive carcinomas have been most elaborate and painstaking. This information explains much of the wide variation of responses of many lesions similar in location and extent of involvement to similar types of radiation treatment. He states that "The derivation of squamous carcinoma from adult squamous cells undoubtedly determines the adult resistant characters of the tumor cells. An extensive group of epidermoid carcinomas arise from stratified epithelium which does not produce keratin or horny material and is called transitional epithelium. This tissue lines the upper uterine cervical canal, the trachea and portions of the larynx, the nasal passages, and the ducts of many glands opening on mucous surfaces. An extensive group of epidermoid carcinomas develops from such epithelium and they regularly exhibit considerable sensitivity. It is, however, often difficult to determine whether a tumor arises from

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transitional epithelium or from squamous, because metaplasia may yield squamous cells in transitional cell tumors, and squamous tumors may be very anaplastic and fail to produce keratin. In the intra-oral group especially, the influence of anaplasia and metaplasia renders the pursuit of histogenesis very uncertain, so that the influence of this factor on sensitivity cannot well be estimated."

Many apparently early mouth cancers, from the standpoint of surgical operability, have been resistant to intensive roentgen-ray and radium treatment, and have developed uncontrollable gland metastasis even after apparent adequate local and regional treatment. In many instances a clinical cure of the primary lesion has been obtained, even with gland metastasis present at the start of treatment. More than 60 per cent of our mouth cancer cases had advanced local and gland involvement at the beginning of treatment. Unless some definite radical technical procedure can offer a further improvement in the end-results of these advanced cases and the early resistant cases, then radiation results must continue to be evaluated in the light of "palliative benefits."

THERAPEUTIC PROCEDURES

Some early mouth cancers have been cured by surgery, cautery, electrodesiccation, radium element in steel or platinum needles, or radium emanation (radon) in gold "seeds" buried into and about the cancer area, as well as surface applications of radium in contact with the lesion. It is now generally agreed that intra-oral cancer is best managed by irradiation (X-ray or radium or both), and sometimes in conjunction with surgery, particularly when there is gland involvement.

In mouth cancer with gland involvement Quick (11) does a complete unilateral neck dissection, with radium "implants" scattered about suspicious points of the wound. He makes no attempt to dissect inoperable nodes.

Regaud (14), at the Curie Institute of Paris, advises removal of enlarged cervical glands by radical *bloc* resection in lip cancers. For cancers of the mouth such resections are done even when glands are not palpable, but if gland invasion from mouth cancer has already taken place, according to microscopical studies, then *bloc* dissection is not done, but treatment is confined entirely to heavy external radium packs.

Of 160 cases of cancer of the mouth, Forssell (6) reports 72 with lymph node metastasis. In none of the 72 cases was there a single one-year cure from radiation alone. When surgery of the glands was combined with radiation he obtained 35 per cent three-year cures, and 30 per cent five-year cures (10 out of 27 cures).

Ewing (4) feels that the practice of leaving nodes until they show clinical signs of involvement seems to be justified in view of our present resources from radiation.

Implantation of radium directly into a single enlarged node, or dissection of a single node if not fixed, have not been popular procedures, but have shown good results, and are justified in selected cases, particularly when the age or physical condition of the patient or the great extent of the primary lesion demands conservatism.

When the question of gland involvement is considered, much stress must be laid on soft, fixed, and infiltrating characteristics, conditions which should readily establish surgical inoperability. Most observers consider a case with bilateral gland involvement as beyond any therapeutic procedure for cure.

We routinely radiate both sides of the neck in all intra-oral cancers, with or without gland involvement. A single firm and freely movable gland is occasionally subjected to a simple excision, but only if it resists intensive cervical radiation or develops after apparent adequate cervical radi-

ation. Surgery for enlarged glands is now generally limited to the lip, cheek, and floor of mouth cases, and only if the primary lesion is within the scope of curability according to our experience with radiation procedures.

SHORT WAVE LENGTH RADIATION

If the biological results of radiation are the effects of a direct action, then some outlook for improving the results in these advanced cases may be had by further increasing the total quantity of radiation. Theoretically the ideal type of radiation is that which causes effective regression of a tumor and at the same time preserves the surrounding normal structures. Many failures are undoubtedly due to insufficient dosage and faulty distribution.

Interstitial radiation will always be complicated by difficulties in getting an exact and uniform distribution of the radium "points." Inability to accurately estimate the scattered and secondary radiation effects in the tissues is outweighed by the information Cutler obtained from histological studies of tissues after varying intensities of radium. Failla (5), Quimby and Pack (12) have established doses with gold filtered radon "seed" implants which are practically within a range of mathematical precision. The clinical application of these data by Quick (11) has shown most gratifying results.

Implantation of radium into and about a neoplastic area is not without danger of tearing tissues and opening up vessels that may lead to metastasis. For this reason we precede interstitial radiation with surface contact radium applications in divided doses over a period of about ten days.

Even with platinum and gold filtration for the radon seeds, the good results are probably an effect of radiosensitive types of cancers, or the caustic effects in the more resistant cases. Our own experience with interstitial radon with 0.2 mm. of gold filter has been very encouraging in selected early cases. We believe its use is largely limited to the floor of the mouth, tongue, soft palate, and tonsillar region and occasionally the cheek. When the local lesion is surgically inoperable, with gland metastasis, then external radiation and surface applications directly in contact with the lesion and surrounding normal structures will prove as adequate as the interstitial treatment.

Lacassagne (9) maintains that unless we admit the destruction of certain kinds of malignant cells by the elective action of roentgen rays and gamma rays of radium, then we should give up the radiotherapy of malignant disease as manifestly inferior to other therapeutic methods. The gamma rays of radium are ordinarily considered as those resulting from filtrations equivalent to 2 mm. of brass or 0.5 mm. of platinum. By the use of 2 mm. of platinum or its equivalent the erythema value is two and a half times greater. While there is no proof of a difference in the biological effect of different qualities of rays, there is a vast difference in the penetration.

Wood (16) concludes from many animal tumor experiments that there is no difference in the lethal effect of long and short wave length radiation. Chamberlain (3) and Holthusen (8) maintain that 500 r with different wave lengths will produce the same biologic effects. This biologic effect may be parallel to ionization in air, but the absorption changes with the wave length according to its penetrative power, which must necessarily alter the distribution of the radiation intensity.

Because of the lessened skin absorption with short wave length rays, Russ and Scott (15) observed that the skin and tumor reactions from short wave length rays did not equal the soft wave length rays until six times as much energy of the short wave length rays had been absorbed, but to cause

the same effect with two groups of wave lengths, only 2.6 times as much energy of the short wave length had to be absorbed.

Because of the recognized increased tissue tolerance and greater penetrative properties of short wave length radiation, the treatment of deep-seated growths with these qualities of rays is a paramount consideration. If prolonged treatment over a period of time is necessary, the tissues are limited in their tolerance for the soft or long wave length radiations.

TECHNIC OF RADIATION OF NECK

In order to fulfill a program that would permit the delivery of greater quantities of radiation to the tissues, two types of radiation were employed on the skin: a combination of roentgen ray, 200 K.V., and 0.5 mm. of copper, and radium packs with a filtration of 3 mm. of lead and 0.5 mm. of silver. This amount of lead and silver has a density equivalent to 2 mm. of platinum or gold. It was found that the combination of these two types of radiation, divided over a period of two weeks, permitted 120 per cent of a dose of roentgen rays and 125 per cent of a dose of radium on the same skin area. These factors equal a total of 245 per cent, an erythema with combined radiation to each side of the neck, or a total of nearly 500 per cent to both sides, with a resulting depth dose in the average neck of 2½ erythema skin doses. The erythema is intense and appears in about twenty-one days and lasts about ten days. In certain advanced cases this radiation has been carried out more slowly (saturation technic, 10) and has been extended for from four to six weeks. Divided doses over this period of time have permitted as much as 350 per cent of combined (X-ray and radium) radiation to a single skin port without damage. The radium packs are 10×15 cm., with 4 cm. distance. If this pack is given at one sitting, the erythema dose is 15,000 millicurie-hours. If divided into four sittings of 48 hours each (5,000 millicuries), a total dose of 20,000 millicurie-hours can be given. Quimby and Pack (13) observed an increased skin tolerance with combinations of different wave length radiations ("soft" and "hard").

Our routine treatment in intra-oral cancers, therefore, is to plan four radium packs of 48 hours each (total 5,000 millicurie-hours) to each side of the neck, making a total of eight packs, with a total dose of 40,000 millicurie-hours. This makes a total time of 384 hours. On the day of rest between radium treatments a roentgen-ray treatment is given to each side of the neck. A total of six 20 per cent doses is given to each side of the neck. Sometimes radium packs alone are used, and as much as from 50,000 to 60,000 millicurie-hours have been given to both sides of the neck in from six to eight weeks, or 15,000 to 30,000 to a single skin port.

TREATMENT OF PRIMARY LESION

Surface applications of radium are made in contact with the lesion and surrounding structures. If the involvement is not greater than that which might be considered as surgically operable, radon in 0.2 mm. gold seeds is embedded into and about the region involved. The full intensity and homogeneous distribution of interstitial radiation is given, but the contact surface applications are not carried to the height of a local reaction—approximately 75 per cent of an erythema dose.

For the advanced cases with local involvement, we believe that surface applications of radium with heavy filtration will be effectual in causing retrogression and palliation with as much certainty as can be accomplished with the interstitial radiation. The use of 2 mm. of platinum admits of

wave length rays more penetrating and less caustic than 0.5 mm. of platinum or its equivalent of 2 mm. of brass, which is the common thickness of filter in general use. For economical reasons the use of lead was selected. These lead capsules can be made wall thickness of 4 mm. to make up an equal density with the lead applicators.

DESCRIPTION OF APPLICATORS

Figure 1 illustrates a combination of applicators fixed to lead strips, or handles, 3

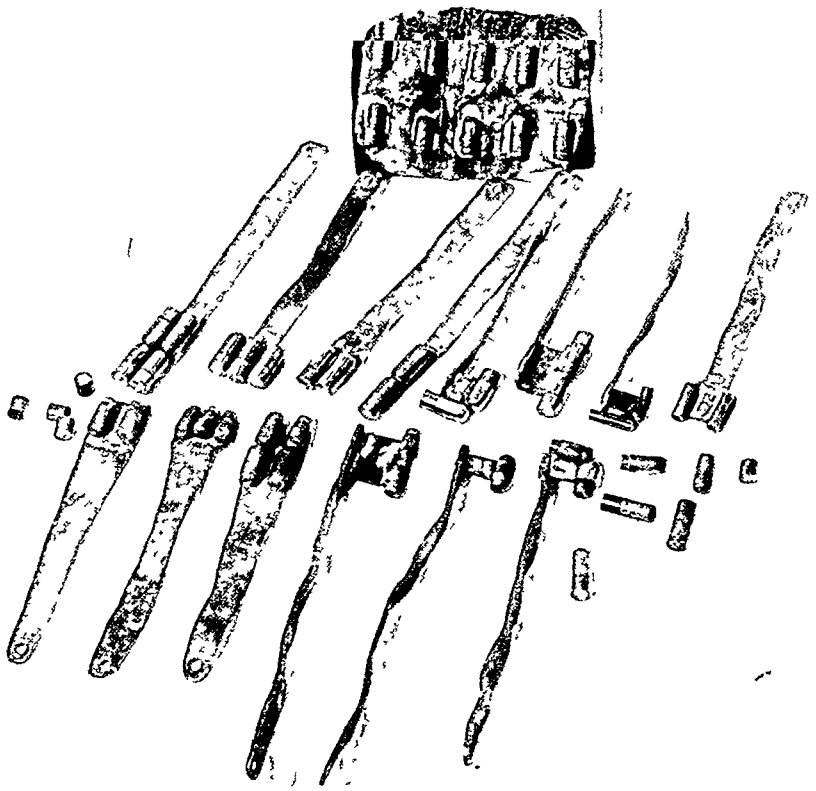


Fig. 1. Stock applicators made of lead; wall thickness, 3 mm. The plaque of ten capsules fixed on a copper plate (0 25 mm. thick) maintains a uniformity and simplicity of application. This same arrangement of applicators made with brass of different thicknesses is also used

to fit any size or number of needles or radon tubes. The radon glass seeds are delivered to us in silver tubes 0.5 mm. thick. The walls of the lead capsules are 3 mm. thick, equivalent to 2 mm. of platinum. All applicators are covered with three layers of pure vulcanizing rubber, 1 mm. thick. The distance from the radium point to the tissues is 5 mm. Because the lead capsules dent and become distorted after long use, they have been duplicated in brass, with a mm. thick. These have been arranged and fixed on copper pegs so that any adjustment on any location of a cancer of the mouth can be adequately made. When these capsules are covered with rubber they are 1 cm. in diameter and are not amenable to easy adjustment with dental molds. We have found that molds are excellent for contact applications, but when large groups of cases are to be treated, and the divided doses are used, then the dangers of prolonged ex-



Fig. 2. Pegged capsules approximating the contour of the floor of the mouth and the surface under the tongue; also the alveologingival folds.

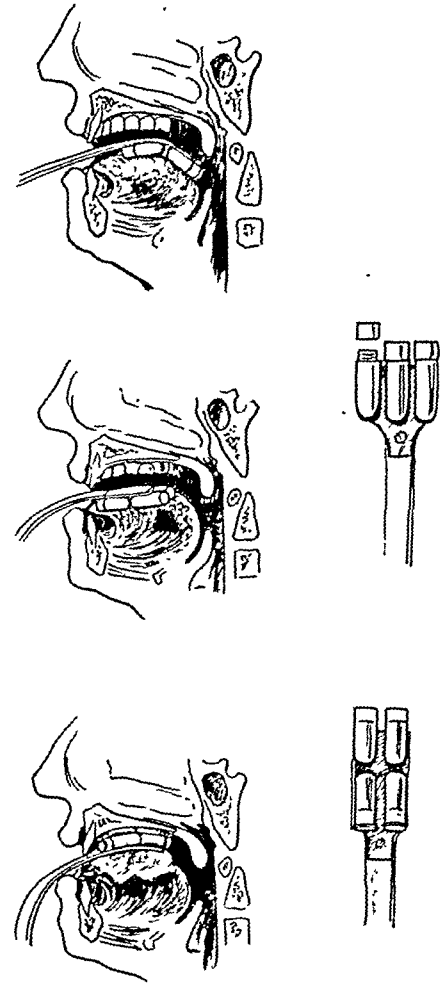


Fig. 3. Stock plaque[illegible] to the dorsum of the tongue, the roof [illegible] mouth, and the cheek.

posure and careless handling become serious factors for the personnel of the department.

Figures 2, 3, 4, and 5 illustrate the various positions that are easily attained. The posterior aspect of the tongue and tonsil are treated after thorough anesthesia with swabs of a 5 per cent solution of cocaine. A rubber band to hold a small gauze pad on the back of the applicator not only insures good fixation by its wedge effect, but serves as a biting point to maintain a position. The peg or prong effect forces the lead capsule into the floor of the mouth, approximating the anterior group of cervical glands. These are made up speedily and accurately and with little danger to the technician. The planning of a treatment with assistants and nurses is facilitated, and a uniformity of technical procedures is developed by an almost automatic and routine system. The "pegged" arrangement of the capsules for stock applicators is varied with single capsules, or double capsules in parallel or at right angles to meet adjustments against the glossopharyngeal fold, the cheek and anterior pillar, or the craters of the upper or lower alveologingival folds. Flat applicators with one, two, three, and four capsules are easily adjusted against the cheek, palate, and dorsum of the tongue.

For external pack treatments a series of copper plates (0.25 mm. thick), 10 by 15

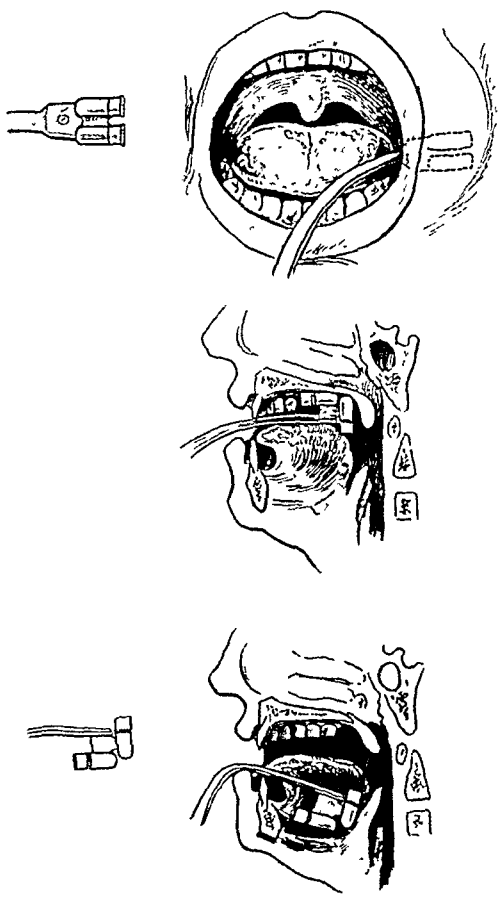


Fig. 4. Pegged capsules at right angles are readily adjustable to the floor of the mouth, against the glossopharyngeal fold, and in the crater of the alveologingival area between the upper jaw and the check.

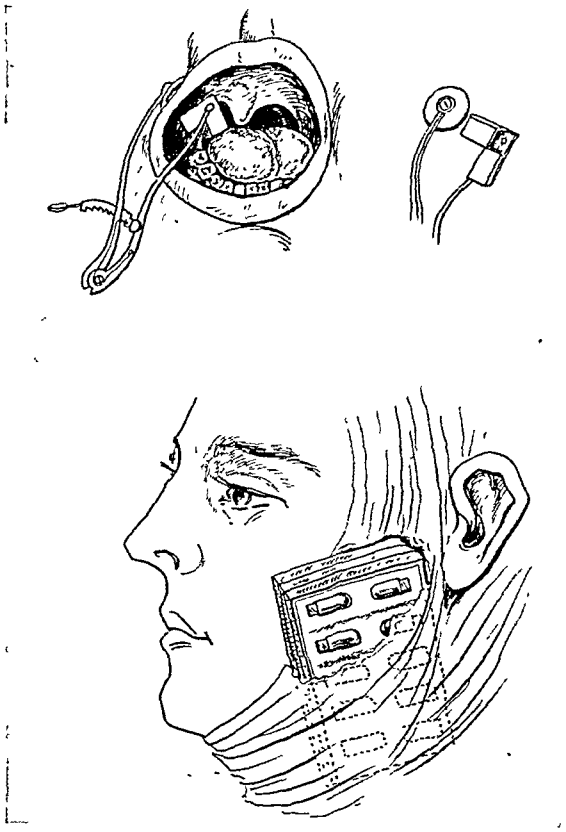


Fig. 5. Tonsil applicators made of brass 2 mm. thick (*above*). Routine fixation of radium pack (*below*).

cm., have been mounted with 10 capsules, distanced so that a homogeneous photographic density is obtained at 4 cm. radium point to skin distance. An average of 100 to 125 millicuries is loaded into a pack, which is routinely applied for 48 consecutive hours, giving an approximate average dose of 5,000 millicurie-hours. As stated above, this filter and distance of pack gives an erythema with 15,000 millicurie-hours (continuous radiation at an initial intensity of 250 millicuries). Ten to fifteen packs can be kept in constant service (with a 2 gram emanation plant). One of the ten capsules on the copper plate has a bore of twice the caliber of the other capsules and a wall thickness of 4 mm. of lead, so that weak tubes of radon can be removed from the silver capsules and loaded into this extra sized capsule. Six to twelve weak glass tubes can thus be passed along to their complete decay. The lead capsules have a loose brass cap with a lead cap 3 mm. thick. All applicators are fixed in a small vise attached to the technician's lead radium shield, and the caps are fixed in position with small strips of adhesive. The brass applicators have been made with screw caps.

The value of contact applicators to fit every location of mouth cancer lies largely in the conservatism of the method in weakened and advanced cases and the ability to use heavy filtrations that eliminate caustic action. It is this principle that is responsible for the working out of this arrangement of surface radiation in mouth cancer, and has permitted the delivery of greater quantities of radiation to the deeper tissues with the

heavier filter. The increased intensity is about two and a half times greater with 2 mm. of platinum than with 2 mm. of brass, and admits of prolonged treatments, following the experience and recommendations of Regaud.

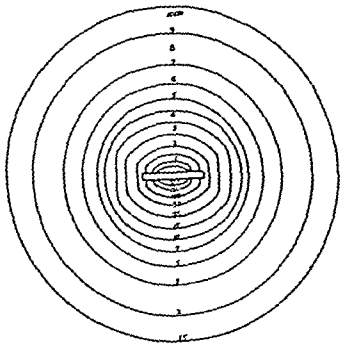


Fig. 6-*A*. Distribution chart of a radium capsule surrounded by tissue; 1.5 mm. brass filtration, 500–1,000 mgm.-hrs. applied; erythema dose designated by 100. (*After Bachem.*)

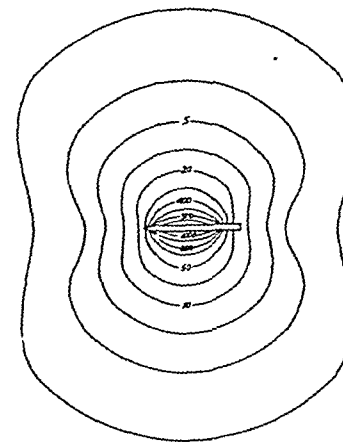


Fig. 6-*B*. Distribution chart of radium needle, surrounded by tissue; 50–100 mgm.-hrs. applied; erythema dose designated by 100. (*After Bachem.*)

The lead capsules with 3 mm. walls and 0.5 mm. of silver produce an erythema with 350 millicurie-hours in one sitting. If this application is divided over a period of ten days, in amounts of 150 to 200 millicuries, a total dose of 1,000 millicurie-hours can be given. Bachem (1) has estimated a depth dose of approximately 50 per cent at 2 cm. depth, with a surface dose of from five to ten erythemas with 1.5 mm. of brass (see Figs. 6-*A* and 6-*B*).

Ionization measurements are not adequate for determining radiation values with filtrations as great as 2 mm. of platinum. Short wave length rays admit less scattered and secondary radiation, but the penetration theoretically is greater, and the tissue tolerance extraordinarily greater, so that a total dosage from three ports about a tongue (Fig. 7) is equal to approximately five erythema doses in the center of the tongue. When this is combined with the external radiation through the neck on both sides, the total radiation in the tongue will reach six to eight erythema doses. The dorsum and under surface of the tongue will be given approximately 3¼ E.S.D. to each of three areas. The plaque of three and four applicators on the dorsum of the tongue requires 1,500 to 2,000 millicurie-hours because of its larger area. A dose of 1,000 millicurie-hours to each area on the floor of the mouth gives a total dose from three ports of 3,000 to 4,000 millicurie-hours. If the posterior aspect of the tongue is treated, an additional 1,500 to 2,000 millicurie-hours will be given. It is significant to point out that each "point" area must be treated with divided doses. We average four applications to each area. Lesser filtration with this intensity of radiation is dangerous and will probably produce a radiation necrosis. Frequently a very advanced cheek or tongue lesion requires further treatment and generally an additional 1,000 millicurie-hours is added. This represents the total for a given area, and when the dorsum of the tongue and the floor of the mouth on both sides are treated, a dose of 5,000 to 6,000 millicurie-hours, 0.5 cm. distance, will be attained with additional treatment, which thus far has been used only in very advanced cases.

The local reaction is marked and usually affects all parts about the area treated. The intensity of the reaction is about equal to the local effects about the cheek, roof of mouth, and tongue following interstitial radiation of the tongue with radon (gold seeds). The reaction appears in about two weeks, which is sooner than with the external surface pack radiation, but the total intensity of radiation is much greater.

We are recommending contact surface applications of radium as another procedure, not to supplant the interstitial use of radium but to supplement it in the early cases, and to use it entirely in the advanced cases, particularly where palliative benefits at most can be expected. We urge the use of surface applicators where large doses are desired, because, with the heavy filtration, increased depth doses can be attained without danger of slough and with a possible outlook of good results such as are not ordinarily obtained with the softer type of radiation.

This technic has been followed for a year. Greater doses are gradually being reached. In many instances there are regressions such as were not obtained with the softer or longer wave length radiation. It is impossible to make a statistical evaluation of advanced cases treated according to this technic up to the present time. Clinical impressions indicate an improvement of sufficient extent to justify intensive procedures along the lines of increasing the total amount of radiation in the tissues. The blood and physical condition of the patient must be considered.

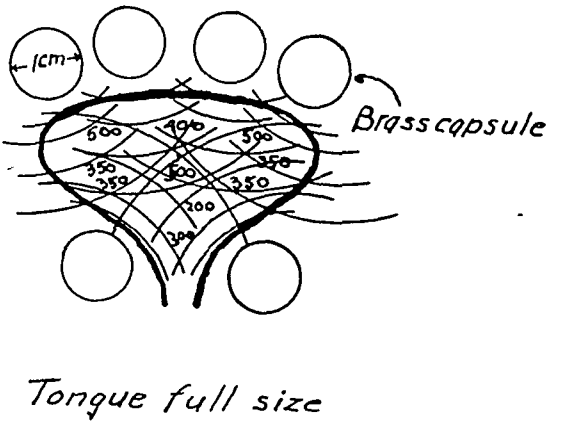


Fig. 7. Illustrating the distribution of intensity of radiation through cross-section of tongue from three surfaces. Brass and lead filters equivalent to the density of 2 mm. of platinum permit a total of 3 erythemas on each area, with an approximate depth dose of 5 E.S.D.

CONCLUSIONS

1. The success of the radiation treatment of intra-oral cancer depends upon the degree of radiosensitivity of the lesion.

2. This sensitivity is noted by rapid responses to radiation as well as histologically by the degree of cellular differentiation—the more highly cellular, the more highly malignant, and, conversely, the more radiosensitive.

3. Improved results in the radiation treatment of advanced cancer of a resistant type will necessitate the administration of still greater quantities of radiation.

4. The use of additional radiation must depend upon short wave length rays, because of their greater penetrative properties, with a definitely increased skin tolerance.

5. The tissue tolerance is still greater with combinations of short wave length rays. No elective action of different types of rays is conceded.

6. Various treatment procedures are discussed.

7. Description and application of an assortment of stock radium containers to meet the requirements of a lesion in any part of the mouth.

8. By external and contact surface radiations alone, five to eight erythema doses can be administered through the center of the tongue.

9. Radium filtrations, with densities equivalent to 2 mm. of platinum, are advocated. This is approximately two and a half times greater than the usual filter of 2 mm. of brass.

10. The success of the radiation treat-

ment of advanced cancer will depend upon such technical procedures as will eliminate dependence for good results on the so-called "caustic effects."

11. Clinical impressions indicate that combinations of short wave length radiation will improve the end-results in advanced and resistant types of intra-oral cancer.

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ADVANTAGES AND LIMITATIONS OF EXTERNAL RADIATION IN THE TREATMENT OF RECTAL CANCER[1]

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EXTERNAL irradiation with radium and high voltage roentgen rays plays an important part in the present-day treatment of rectal cancer. This type of radiation is capable of producing an eradication of the disease in tumors of the most radiosensitive nature, and varying degree of growth-restraint in those that are more radioresistant. It is the ideal form of radiation in that no trauma is produced and no infection introduced into the tumor or surrounding tissues. The beam of radiation includes a larger area of lymphatics than can be reached by surgical dissection or by other forms of radiation. An improvement is frequently noted coincident with the beginning of treatment. Seldom is the constitutional effect upon the patient sufficiently severe to interfere with his daily routine.

Nevertheless, in spite of the fact that external radiation exerts a beneficial effect upon rectal cancer, it should be considered as only the first step of radiation therapy and not an individual method of treatment. Further radiation is required in over 80 per cent of cases. The limitations of this method are largely due to (1) the radioresistant nature of rectal carcinomata, (2) the depth of these tumors and the degree of tolerance of the skin to radium and roentgen rays.

There is a slight variation in the depth of tumors and in the tolerance of the skin to irradiation, while the radiosensitivity of rectal cancer varies widely. The varied histology of early uncomplicated growths is such as to suggest at once a wide range in the probable radiosensitivity. With the onset of deep-seated infection and ulceration, the importance of this factor is greatly reduced. Infection spreads more rapidly in cellular or anaplastic cell carcinomata than in the more adult types. The tolerance of the skin to irradiation appears to be influenced by its vascularity. Usually, the skin of the thin anemic patient will withstand larger dosage than that of the obese. The percentage of the skin dosage which reaches the tumor mass depends upon the size of the pelvis and the location of the growth.

High voltage roentgen rays have been extensively—in fact, almost exclusively—employed for this form of therapy. Experimentally, there does not appear to be a great difference in the effect of high voltage roentgen rays and the gamma rays of radium. Clinically, however, there is a marked advantage afforded by the gamma rays. Since the 4 gram radium element pack has been added to the Memorial Hospital equipment, so that external radium irradiation could be more freely employed, there has been a marked improvement in the effect produced on rectal cancer by external treatment. Nevertheless, this amount of radium is sufficient for only a small number of the patients applying for treatment: except in selected cases, it has been necessary to supplement a part of the applications by high voltage roentgen rays. The combined use of radium and roentgen rays, in which radium forms the greater part of the dosage, has its advantages. There is an unlimited supply of roentgen radiation available at a comparatively low cost. A considerable percentage of the dosage, when desired, can be given within the first week of treatment. The short time required to administer an erythema dose of roentgen rays by the water-cooled machine is greatly appreciated by the

[1]Read before the Radiological Society of North America at the Fifteenth Annual Meeting, at Toronto, Dec. 2–6, 1929.

nervous and debilitated patients who find it rather trying to lie quiet in one position for a two-hour daily radium application. By combining the two agents (1) a larger dosage may be administered at the site of the tumor, because of the increased tolerance of the skin to the two methods.

Radium radiation is given at 15 centimeters from the skin by means of the element or emanation pack. Sufficient filter to eliminate all but the most penetrating gamma rays is employed, and lateral screening to prevent undue body irradiation. Usually, two portals of entry, an anterior and a posterior, are employed in routine radium applications. The number of portals is increased to three or four when larger dosage of gamma radiation is desired. Because of the shape of the pelves and the location of the tumors, the dosage of gamma radiation is not increased in proportion to the number of portals employed.

High voltage roentgen rays are administered through six portals, which include the greater part of the circumference of the pelvis. When tumors are situated low in the rectum, a perineal field is also employed. The usual factors of these applications are: 60 minute exposures, 185 kilovolts, 50 cm. skin target distance, 4 milliamperes of current, filtered by ½ mm. of copper and 1 mm. of aluminum. The time of exposure may be extended from 60 to 80 minutes, or, if a water-cooled machine is employed which operates at 30 milliamperes, the time of exposure is correspondingly decreased.

The actual percentage of the skin dosage which reaches the center of the tumor may be calculated from careful measurements. A tumor of the mid-rectum in a pelvis of medium size receives about 1.75 per cent of the skin dosage at each one of the seven portals. The same tumor will receive about 70 per cent of a skin dose of gamma radiation when the radium pack is applied over medial anterior and posterior fields. Therefore, when erythema doses of roentgen rays and gamma rays are administered over seven portals, the total amount of radiation which the tumor will receive is between 2.25 and 2.50 erythema doses.

The dosage and technic of application will depend upon clinical and pathological factors, which indicate the part that external radiation may be expected to play in bringing about the result. For simplicity of description, cases are separated into two groups: (1) those in which external radiation forms the first step of radiation therapy and (2) those in which external radiation is the only radiation therapy required.

There are three classes of cases in which external radiation constitutes the first step of radiation therapy, the cancers in all instances being comparatively radioresistant. These cases are classified in accordance with the result expected, by supplementing external radiation with other forms of treatment, into the following groups: (1) patients that present the possibilities of a clinical cure; (2) patients in whom a high degree of palliation is expected; (3) patients in whom only a moderate degree of palliation can be anticipated. The first two groups are given heavy preliminary external radiation, while the latter group receives a smaller amount. By heavy dosage is meant a pelvic cycle of roentgen rays consisting of seven portals, and radium applications of from 60,000 to 75,000 milligram-hours over each of two or more portals. The roentgen-ray applications are given daily or on alternate days and are followed by daily applications of 8,000 milligram-hours of radium until the full dose has been delivered.

This dosage produces varying degrees of alteration in the primary tumor. The majority of growths show a reduction in size, a lessening or disappearance of the ulcerating area, while the external limits are more

easily defined. Occasionally, a fixed tumor will be found to have become movable. These changes indicate a marked growth-restraint and a decrease in the degree of infection and surrounding inflammatory reaction. This local improvement is accompanied by a decrease in symptoms and an improvement in the general physical condition of the patient, favorable changes which facilitate further radiation therapy and offer an additional advantage to surgical interference, should the latter procedure be deemed advisable.

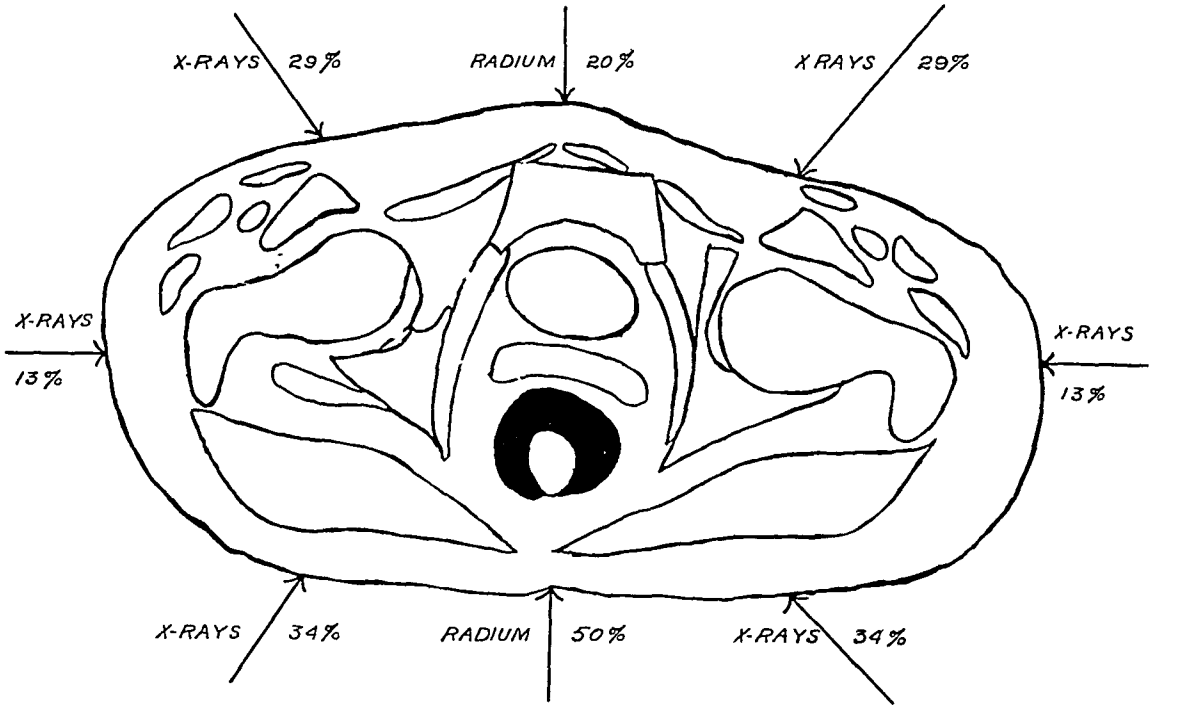


Fig. 1. Cross-section of a medium sized pelvis showing the direction of beams of radiation, with the approximate percentage of skin dosage absorbed in the center of the tumor.

While heavy preliminary external radiation is most valuable in the above two groups, a more satisfactory result is obtained in cases suitable for only moderate palliation by employing smaller preliminary dosage. This type of case usually receives a pelvic cycle of roentgen rays, with an interval of two or three days between applications. After about one week, radium applications are commenced, the total dosage for each portal seldom exceeding 50,000 milligram-hours. Patients in this group are in a less favorable physical condition and may not be able to withstand intensive applications. The object is to reduce the severity of symptoms, make the patient more comfortable, and, whenever possible, to prolong life. This is obtained with least embarrassment to the patient by moderate dosage of external radiation repeated at varying intervals, together with small repeated doses of interstitial radiation. Small preliminary external doses allow the patient to gain in weight and strength so that further treatment may be undertaken. Moreover, the skin will stand a much larger amount of irradiation when the applications are extended over a long period of time. Fractional doses may be repeated at comparatively frequent intervals. However, careful consideration must be given to the skin in all instances. Permanent damage is more apt to be done by small repeated doses than

by a large preliminary application, particularly if the fractional doses are prolonged over a considerable period of time.

There are two groups of cases in which external radiation may be used as an individual method of treatment: the most favorable and also the most unfavorable cases of rectal cancer. By the "most favorable" is meant cases in which a clinical cure of many years' duration may be obtained by this comparatively simple form of therapy. The cancer cells in this group are sufficiently radiosensitive to be eradicated by 200 or 250 per cent of an erythema dose of radiation. The number of these very radiosensitive cancers is small, being less than 1 per cent. The dosage and technic in this type of case correspond to that which has been described above as heavy external radiation. There is an early response to treatment and patients are free of symptoms after a few weeks, although it may require several months for the preliminary mass to completely disappear.

The most unfavorable cases receive the greatest amount of palliation from external radiation. Because of the extent and nature of the disease, and the poor physical condition of the patients, other forms of radiation are contra-indicated. These debilitated patients often show considerable temporary improvement following adequate dosage of external radiation. The dosage and the intervals between applications are governed by the condition of the patient and the response to treatment. This does not mean that all very advanced cases should be treated by irradiation—a certain number, unfortunately, are too far advanced for any worth-while palliation by any form of treatment.

SUMMARY

1. External radiation constitutes the first step in radiation therapy of all rectal cancer, and in certain selected cases may be the only form of treatment necessary.

2. The effect of external applications is limited by the depth of the tumor, the tolerance of the skin to irradiation, and by the radioresistant nature of the majority of rectal cancers.

3. External radium radiation is more effectual than high voltage roentgen rays. The two types of radiation may be combined advantageously.

4. The dosage and intensity of application are governed by the clinical and histological features of the case.

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RESULTS OBTAINED IN THE TREATMENT OF CARCINOMA OF THE CERVIX UTERI WITH RADIUM AND ROENTGEN RAYS FROM 1915 TO 1924, INCLUSIVE[1]

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IN this report we are compiling the results of treatment of carcinoma of the cervix with radium, considering only cases treated at least five years ago. All cases in which treatment with radium was employed at The Mayo Clinic for the ten-year period from 1915 through 1924 are included. This paper is supplementary to the report given in July of this year at the meeting of the American Radium Society (1); we are now adding our 1924 results.

During the decade mentioned, 1,094 patients were treated, 1,001 (91.5 per cent) of whom have been traced. We have separated the cases into four major groups: operable, borderline, inoperable, and modified. The modified group includes all cases in which the lesions were modified by previous treatment before we first saw the patients; previous treatment may have been by operation, cautery, radium, roentgen ray, or other means.

In the course of this ten-year period no treatment was applied in 167 cases, due to various reasons, such as recent treatment elsewhere or moribund condition of the patient. In 132 cases, operation, treatment by cautery, or treatment by some other method was carried out at The Mayo Clinic; however, irradiation was not done in these cases. These surgical measures, without irradiation, were applied during the earlier years represented in this review. In 1924, the last year considered, only three patients who were operated on did not receive radium.

We will not discuss details of treatment, except to say that the usual complete treatment employed in the inoperable group consists of six to eight applications in all, given, in turn, interstitially, intracervically, within the uterus, and vaginally. The total amount of irradiation is 5,000 to 6,000 milligram-hours. This is given over a period averaging three weeks, and is followed by a course of high voltage roentgen-ray treatment. Detailed factors in treatment have been given in a recent article (2).

Table I gives the age incidence according to groups. In Table II we have listed the number of survivors in all groups by years. Thus, twenty-nine patients treated in 1924 have survived five years, forty-two treated in 1923, twenty-nine in 1922, and so on down to our first year, 1915, in which group one patient survived five years. The right-hand column lists the number of patients now living.

Table III records the results of treatment according to groups. We are tabulating on the basis of 1,001 patients who were traced out of a total of 1,094. In the small, operable group, 75 per cent of patients survived five years. Of the borderline cases, 61.53 per cent lived five years. The other two groups were larger: in the inoperable group, 21.49 per cent of the patients were living after five years; in the modified group, there were 24.82 per cent five-year survivals. The discrepancy between the results in the early and borderline groups, on the one hand, and the results in advanced cases on the other, emphasizes the necessity for early diagnosis. In the modified group, results have been slightly better than in the inoperable group. This table demonstrates, completely, the five-year results; the seven-

[1]Read at the Fifteenth Annual Meeting of the Radiological Society of North America, at Toronto, Canada, Dec. 2–6, 1929.

TABLE I

AGE INCIDENCE

Age, years	Modified group		Inoperable group		Borderline group		Operable group	
	Cases	Per cent	Cases	Per cent	Cases	Per cent	Cases	Per cent
20-24			1	0.16				
25-29	14	2.99	9	1.49				
30-34	55	11.75	25	4.15				
35-39	65	13.88	66	10.95	1	7.14	2	22.22
40-44	87	18.58	86	14.26	1	7.14	1	11.11
45-49	78	16.66	107	17.75	2	14.28	1	11.11
50-54	78	16.66	106	17.57	4	28.57	1	11.11
55-59	54	11.53	98	16.25	3	21.42	3	33.33
60-64	27	5.76	57	9.45	1	7.14		
65-69	7	1.49	36	5.97	1	7.14	1	11.11
70-74	3	0.64	9	1.49	1	7.14		
75-79			3	0.49				
Total	468		603		14		9	
Average age years	46.03	±0.29	50.37	±0.27	54.39	±1.62	50.84	±2.17

TABLE II

SURVIVORS OF ALL GROUPS BY YEARS

Year treated	Total cases	Years of life after treatment[2]													
		1916	1917	1918	1919	1920	1921	1922	1923	1924	1925	1926	1927	1928	1929
1915	5	1	1	1	1	1	1	1	1	1	1	1	1	1	1
1916	63		27	14	10	7	5	5	5	5	5	5	5	5	5
1917	93			51	28	21	18	17	14	13	11	10	9	8	6
1918	135				61	39	28	22	19	17	13	11	9	9	7
1919	145					77	44	32	21	20	18	18	15	15	10
1920	151						85	61	43	38	37	32	28	27	16
1921	118							64	52	46	40	40	36	35	20
1922	136								74	53	40	31	29	25	16
1923	135									83	60	51	43	42	27
1924	113										61	39	36	31	29

[2]The figures enclosed in black lines indicate the numbers of patients living five years after treatment.

year and ten-year results are necessarily fragmentary.

In Table IV we have summed up the five-year cures by groups. All 1,094 cases, considered together, show 21.84 per cent of five-year cures. Dropping out the modified group, the figure declines very slightly to 21.08 per cent. The operable and borderline five-year cures combined reach 60.86 per cent. But if just the traced cases are considered, 1,001 in all, our figures are higher, since, when we considered the 1,094 cases, we regarded all untraced patients as having died and we did not record them beyond the dates of their last examinations or letters. Thus, the percentages of five-year cures rise to 23.87, 23.15, and 66.66, respectively, and these percentages are more

TABLE III

RESULTS OF TREATMENT BY GROUPS

Group	Year	Total cases	Patients traced	Lived 3 years		Lived 5 years		Lived 7 years		Lived 10 years	
				Cases	Per cent	Cases	Per cent	Cases	Per cent	Cases	Per cent
Modified	1915	4	4	1	25.00	1	25.00	1	25.00	1	25.00
	1916	39	38	8	21.05	4	10.52	4	10.52	4	10.52
	1917	55	53	17	32.07	15	28.30	12	22.64	8	15.09
	1918	69	62	16	25.80	10	16.12	7	11.29	4	6.45
	1919	59	55	14	25.45	12	21.81	10	18.18	7	12.79
	1920	60	53	21	39.62	19	35.84	15	28.30		
	1921	36	33	10	30.30	9	27.27	7	21.21		
	1922	59	56	16	28.57	13	23.21	8	14.28		
	1923	48	44	18	40.90	15	34.09				
	1924	39	33	10	30.30	9	27.27				
	Total	468	431	131	30.39	107	24.82	64	14.84	24	5.56
Inoperable	1915	1	1								
	1916	24	24	2	8.33	1	4.16	1	4.16	1	4.16
	1917	38	34	4	11.76	2	5.88	1	2.94	1	2.94
	1918	65	60	11	18.33	8	13.33	5	8.33	4	6.66
	1919	85	80	18	22.50	8	10.00	8	10.00	3	3.75
	1920	89	80	21	26.25	17	21.25	12	15.00	1	11.11
	1921	74	68	31	45.58	26	38.23	23	33.82		
	1922	76	68	23	33.82	15	22.05	8	11.76		
	1923	85	81	32	39.50	26	32.09				
	1924	66	53	21	39.62	15	28.30				
	Total	603	549	163	29.69	118	21.49	58	10.56	10	1.63
Borderline	1918	1	1	1	100.00	1	100.00	1	100.00	1	100.00
	1919	1	1								
	1921	8	8	5	62.50	5	62.50	5	62.50		
	1922	1	1	1	100.00	1	100.00				
	1923	2	2	1	50.00	1	50.00				
	1924	1									
	Total	14	13	8	61.53	8	61.53	6	46.15	1	7.69
Operable	1920	2	1	1	50.00	1	50.00	1	50.00	1	50.00
	1924	7	7	5	71.42	5	71.42				
	Total	9	8	6	75.00	6	75.00	1	12.50	1	12.50
Grand total		1094	1001	(91.50 per cent)							

TABLE IV

FIVE-YEAR CURES BY GROUPS

Group	Cases	5-year cures, number	Per cent	Patients traced	5-year cures, number	Per cent
Operable, inoperable, borderline, and modified	1094	239	21.84	1001	239	23.87
Operable, inoperable, and borderline	626	132	21.08	570	132	23.15
Operable and borderline	23	14	60.86	21	14	66.66

nearly correct, as many untraced patients are probably still living.

Table V records the length of life in connection with the pathologic nature of the lesion. In one of the nine operable cases, no microscopic examination of the lesion was

TABLE V

CLASSIFICATION OF LENGTH OF LIFE BY GRADE OF PATHOLOGIC CHANGE

Group	Microscopic diagnosis	Cases	Impossible to be traced	Died within 1 year	Died, time not stated	Length of life, years					
						3	5	6	7	9	10
Modified	Epithelioma, not graded	28	4	5	3	14	12	12	9	8	7
	Epithelioma, graded 2	31	2	6	4	10	9	6	5	4	4
	Epithelioma, graded 3	104	6	21	13	39	28	18	14	7	4
	Epithelioma, graded 4	73	5	20	10	19	15	12	10	4	3
	Adenocarcinoma, not graded	6	2	1		4	3	3	3	2	2
	Adenocarcinoma, graded 1	3				2	2	2	1	1	
	Adenocarcinoma, graded 2	11		1		5	5	4	3	1	1
	Adenocarcinoma, graded 3	5				4	4	4	3	1	1
	Adenocarcinoma, graded 4	1				1	1	1	1		
	Adenocarcinoma and epithelioma, graded 2	1									
	Adenocarcinoma and epithelioma, graded 3	4		2		1	1				
	Total	267	19	56	30	99	80	62	49	28	22
	No biopsy	201	17	78	21	32	27	17	15	7	2
	Grand total	468	36	134	51	131	107	79	64	35	24
Inoperable	Epithelioma, not graded	14	2	4		2	1				
	Epithelioma, graded 2	35	3	11	4	11	7	5	4	1	
	Epithelioma, graded 3	166	17	39	18	51	43	33	22	4	1
	Epithelioma, graded 4	107	12	30	9	40	28	14	10	3	1
	Adenocarcinoma, not graded	3	1			2	2	1	1	1	1
	Adenocarcinoma, graded 1	1									
	Adenocarcinoma, graded 2	10		1	2	6	4	2	2	1	
	Adenocarcinoma, graded 3	3		1							
	Adenocarcinoma, graded 4	1		1							
	Adenocarcinoma and epithelioma, graded 2	1				1	1	1			
	Adenocarcinoma and epithelioma, graded 3	1				1					
	Total	342	34	87	33	114	86	56	39	9	3
	No biopsy	261	20	95	26	49	32	24	19	14	7
	Grand total	603	54	182	59	163	118	80	58	23	10
Borderline	Epithelioma, not graded	1	1								
	Epithelioma, graded 3	5			1	3	3	3	3		
	Epithelioma, graded 4	2				2	2	2			
	Total	8	1		1	5	5	5	3		
	No biopsy	6		2		3	3	3	3	1	1
	Grand total	14	1	2	1	8	8	8	6	1	1
Operable	Epithelioma, not graded	3				3	3				
	Epithelioma, graded 2	1				1	1				
	Epithelioma, graded 3	3	2			1	1				
	Epithelioma, graded 4	1		1							
	Total	8	2	1		5	5				
	No biopsy	1				1	1	1	1	1	1
	Grand total	9	2	1		6	6	1	1	1	1

made; likewise, this confirmatory measure was not employed in six of fourteen borderline cases, in 261 of 603 inoperable cases, and in 201 of 468 modified cases. Biopsy is not essential to diagnosis; nevertheless, of late years we usually take tissue to allow of correlation of results with the histologic pathology. In modified cases there fre-

TABLE VI

THREE-YEAR AND FIVE-YEAR CURES BY GRADE OF PATHOLOGIC CHANGE

Group	Microscopic diagnosis	Total cases	Patients traced	Lived 3 years	Per cent	Lived 5 years	Per cent
Modified	Epithelioma, graded 2	31	29	10	34.48	9	31.03
	Epithelioma, graded 3 and 4	177	166	58	34.94	43	25.90
	Adenocarcinoma, graded 1 and 2	14	14	7	50.00	7	50.00
	Adenocarcinoma, graded 3 and 4	6	6	5	83.33	5	83.33
Inoperable	Epithelioma, graded 2	35	32	11	34.37	7	21.87
	Epithelioma, graded 3 and 4	273	244	91	37.29	71	29.09
	Adenocarcinoma, graded 1 and 2	11	11	6	54.54	4	36.36
	Adenocarcinoma, graded 3 and 4	4	4				
Borderline	Epithelioma, graded 3 and 4	7	7	5	71.42	5	71.42

quently is surface healing and to obtain tissue we would have to cut through barriers of protective tissue, which we dislike to do.

From Table V it appears that among the 625 cases in which microscopic examinations were made, in 574 (91.84 per cent) epitheliomas were found; in 44 (7.04 per cent) adenocarcinomas, and in seven (1.12 per cent) mixtures of the two. Further analysis shows that among all of these malignant lesions, 476 (76.16 per cent) were graded 3 or 4 according to Broders' classification; 94 lesions (15.04 per cent) were graded 1 or 2, and 55 lesions (8.80 per cent) were not graded.

Table VI gives the three-year and five-year cures by grade of malignancy.

A study of our mortality in hospital was made. Our treatment extends over a period of three or more weeks and the patients are watched carefully for complications. Complications develop in a few patients each year; we encounter hemorrhage, pelvic cellulitis, pyometritis, peritonitis, and so forth. Treatment is halted at once at the outset of any of these accidents and is either abandoned or cautiously continued, as the outcome warrants. During the decade reviewed, mortality in hospital has been very low: five cases (1.06 per cent) in the modified group of 468 cases and six cases (0.99 per cent) in the inoperable group of 603 cases. None of the patients in the operable and borderline groups died.

SUMMARY

We have reviewed the cases of carcinoma of the cervix treated with radium at The Mayo Clinic during the years 1915 to 1924, inclusive, and have epitomized the results of treatment. The total number of patients treated was 1,094; of these, 1,001 (91.50 per cent) have been traced. We have divided the total into four groups: operable, borderline, inoperable, and modified. Of the traced cases, our five-year cures compose 75 per cent of the operable group, 61.53 per cent of the borderline, 21.49 per cent of the inoperable, and 24.82 per cent of the modified. Of the 625 cases (57 per cent of all cases) in which microscopic examinations of the growths were performed, epitheliomas were found in 574 (91.84 per cent), adenocarcinomas in 44 (7.04 per cent), and mixtures of the two in seven (1.12 per cent). Lesions graded 3 and 4 totaled 476 cases (76.16 per cent); 94 (15.04 per cent) were of grades 1 and 2, and 55 (8.80 per cent) were not graded. In this series, patients with adenocarcinoma (of all four grades) appear to have had a better rate of survival than those with epithelioma. Patients with epithelioma graded 3 and 4 had

a slightly better rate of survival than those with epithelioma graded 2, except for the results after five years among the modified cases. Finally, the rate of mortality in hospital was 1.06 per cent among the modified cases, 0.99 per cent for the inoperable group, and zero for the operable and borderline groups.

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CARCINOMA OF THE CERVIX[1]

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RADIATION therapy for the treatment of malignant disease of the cervix was established at the Memorial Hospital in 1915, under the direction of Dr. Harold Bailey. During the past fifteen years about two thousand cases of carcinoma of the cervix have been under observation.

The principle of cross-firing the lesion from multiple foci was instituted by Bailey, and he was one of the first gynecologists to attack cancer of the cervix by the routine application of radiation externally around the pelvis as well as by means of vaginal applicators, intracervical capsules, and interstitial radiation by needles or seeds.

During the first seven years, from 1915 to 1921, under Bailey's direction, radium was the only source of radiation employed.

From January, 1922, to date, under the writer's supervision, the use of radium as the source of external radiation has been omitted and the roentgen ray has been substituted for it. This change in routine was first forced upon us because of the large number of patients applying for treatment. The cervix cases were requiring so much radium in the pack and in vaginal applicators that the supply for other cases was inadequate, or frequently could not be obtained at all.

After consultation with Dr. G. Failla, of the Department of Physics, it was determined that insofar as percentage of skin erythema dose was concerned at a point in the pelvis 10 cm. below the surface, we could obtain a greater percentage even with the low voltage X-ray machine in use at that time than was being obtained with the small radium block then in use for external application. Moreover, from the standpoint of economy in time of treatment and cost to patient there was a decided advantage in favor of the roentgen ray.

The plan of treatment followed for the past eight years, therefore, has consisted of a combination of radium at the site of the primary lesion and X-ray applied through multiple foci about the pelvic girdle. The thought underlying this is the desire to irradiate, as intensively as possible, both the lesion and the lymphatic drainage area about it, in order to control not only the primary disease but also the inevitable parametrial metastasis.

Since at least two-thirds of all cases already have parametrial involvement when first seen, it would seem highly desirable to attempt at least to inhibit the growth activity in these areas, even if the disease is too extensive to be cured. During the past three or four years high voltage X-ray has replaced low voltage; as a result we estimate that approximately 38 per cent of a skin erythema dose is obtained 10 cm. below the surface from a single exposure.

Figure 1 indicates in diagrammatic form the varying amounts of radiation obtained from high voltage X-ray in different portions of the pelvis measured in skin erythema doses. The factors are 200 K.V., ½ mm. copper, 1 mm. aluminum, 50 cm. target skin distance, 4 milliamperes, 60–80 minutes treatment, 15 × 15 cm. field.

This diagram indicates that a minimum of 100 per cent and a maximum of 120 per cent of a skin erythema dose is distributed throughout the greater portion of the pelvis, extending from the middle of the acetabulum on one side to the corresponding place in the opposite side. The high percentage indicated from the cervix to the sacrum

[1]Read before the Radiological Society of North America at the Fifteenth Annual Meeting, at Toronto, Dec. 2–6, 1929.

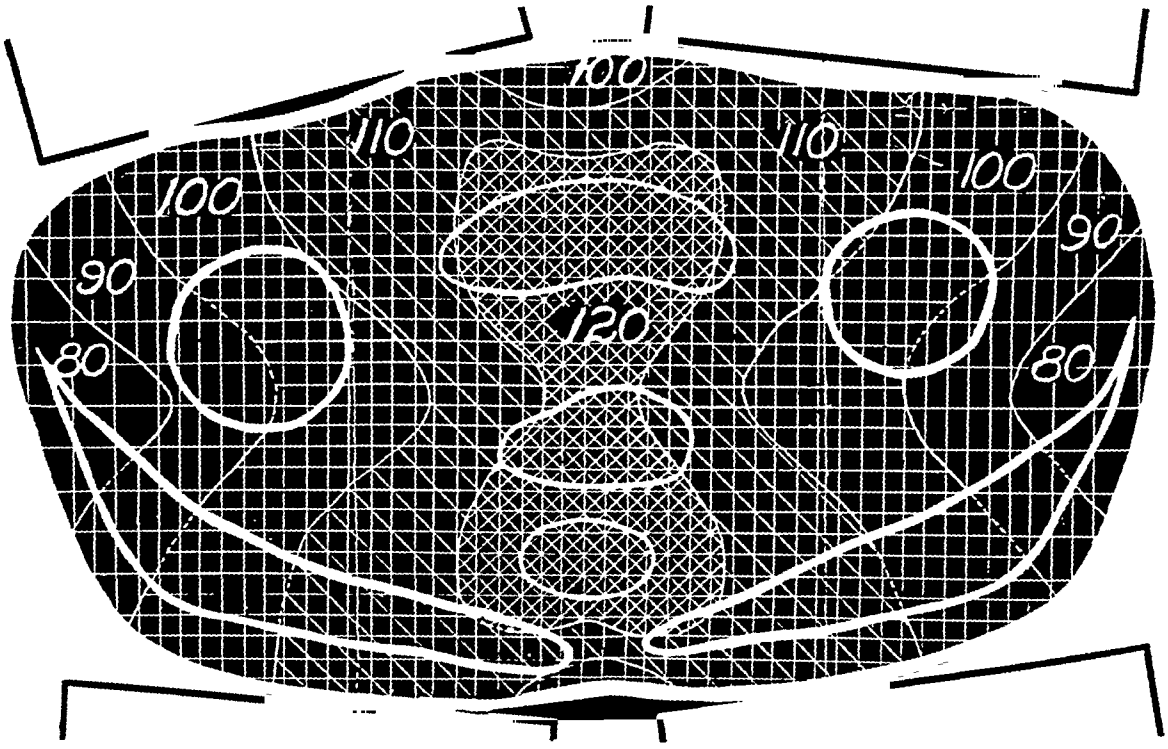


Fig. 1. Distribution of radiation in medium-sized female pelvis when irradiated with high voltage X-rays through four portals, as shown: 200 K.V., 0.5 mm. copper and 2.5 mm. aluminum filter, 50 cm. target-skin distance, 15×15 cm. fields, 1 erythema dose for each portal.

would seem to be quite important. This area includes a segment of the parametrium embracing the uterosacral ligaments, the perirectal area, and the retroperitoneal lymphatic glands anterior to the sacrum. Lesions in the posterior half of the cervix are prone to send off early metastases to this area and although the lesion may seem to be an early one, the case may do badly. Of course, it is to be realized that these figures refer only to the percentage of radiation obtained with the high voltage X-ray cycle and do not include the value represented by the radium applications.

Those figures may be to some extent appreciated from a study of Figure 2 and the accompanying tables. The figures given therein include the total value of the combined radiation with radium and X-ray, as applied by us, at different points, with relation to the source of radiation. While these values are all approximate, it is interesting to note that the lowest value indicated is 335 per cent of a skin erythema dose and is obtained 5 cm. from the capsule in the cervix. Also, of the total radiation received at this point (15) 30 per cent is attributable to X-ray, whereas Point 2, 1 cm. distant from the cervical capsule, receives 5,690 per cent of a skin erythema dose, of which only 2 per cent is of X-ray origin and 98 per cent is derived from radium.

A study of Figures 1 and 2 and the tables accompanying the latter enables us to appreciate the relative as well as the actual values of different methods of application of radiation therapy. They also indicate the heavy radiation obtained by cross-firing from several foci and the great ease with which the total dosage in any given area can be enormously increased by the use of interstitial radiation with needles or filtered implants, such as gold or platinum seeds.

We are of the opinion that the large number of advanced cases constantly seen, because of the difficulties of early diagnosis, makes it extremely improbable that we shall obtain more than 40 to 50 per cent of five-

year cures by radiation or surgery, singly or combined, in the favorable cases. By favorable cases we mean the so-called clinically early and borderline groups.

per cent with this operation, as against a mortality of 1½ to 2 per cent from radiation therapy. Moreover, there are very few surgeons who can hope to achieve the high

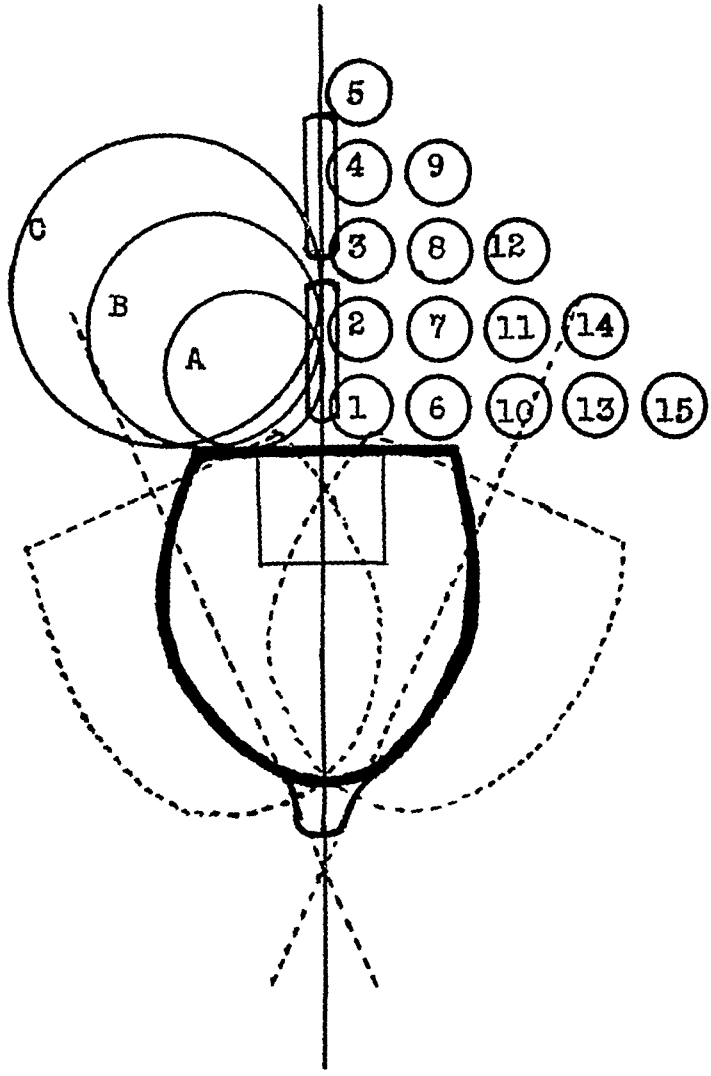


Fig. 2. Bomb and cervix tandem in position (actual size). See Table I for doses delivered at numbered points, also for millicuries in gold seeds necessary to deliver 100, 500, and 1,000 per cent erythema dose throughout lettered spheres. One thousand millicurie-hours from bomb in each position; one thousand millicurie-hours from upper tube of tandem; two thousand millicurie-hours from lower tube of tandem.

When we speak of surgery as giving such a high percentage of five-year cures we refer to the radical Wertheim operation, and one must not, of course, overlook the high associated primary mortality of about 15 to 20

percentage of cures referred to with hysterectomy, whereas practically all specialists of experience in radiation therapy seem to obtain about 40 to 50 per cent of five-year cures.

Unfortunately five-year freedom from recurrence does not always mean a cure. Recurrences are seen in the parametrial lymph glands in the sixth, seventh, and eighth year after treatment. Local recurrences in the cervix after the fifth year are, however, quite unusual.

In all instances in which the disease is too advanced to attempt other than palliation of symptoms, chief reliance is placed on high voltage X-ray treatment. The cycle may be repeated two or three times at intervals of six weeks. If the lesion seems to be radiosensitive in its response to the X-ray, occasionally vaginal applications of radium are then also given.

Our routine procedure in favorable cases has been radium first, followed promptly by X-ray; the latter cycle is repeated once or twice at intervals of six to eight weeks after the first cycle. The cycle now consists of five exposures, four of which include the entire circumference of the pelvic girdle, the fifth being centered posteriorly over the spine of the third lumbar vertebra and is given for its effect upon the prevertebral lymph glands in this area.

Postmortem investigations in patients who have died with carcinoma of the cervix have revealed extensive involvement of the retroperitoneal glands anterior to the lumbar spine. This involvement has seemed to be largely responsible for the persistent and very severe pain which these patients suffer for months before death. We are hopeful that by adding this lumbar exposure to the full pelvic cycle something of value will be gained for the patient.

Numerous writers have reviewed the histology of their cases of cervical cancer, and there seems to be a consensus of opinion upon certain points.

First, the lesions are almost exclusively of the squamous epidermoid variety, with a very small number of adenocarcinomata—not over 3 to 6 per cent—which arise from the cells in the cervical glands.

Second, the squamous epidermoid variety can be readily divided into three large histologic groups according to variations in cellular structure and characteristics. Various names have been given to these groups by different writers, but there is no diversity of opinion on the histologic criteria of the individual groups.

Briefly, Group 1 (adult, spinal, ripe) is composed of tumors in which the predominant cell type is a fully developed, mature, adult squamous cell, with more or less tendency to pearl formation. The cells and nuclei resemble each other and have similar staining qualities. These cases comprise about 20 per cent of the total. Group 2 (plexiform, transitional, midripe) consists of cases in which the histologic appearance is changing from that of a mature cell to one that is less mature, and the cells vary more in size and staining qualities. Mitoses are more in evidence and in the majority of cases the histologic picture suggests a pattern or architectural structure of plexiform type. This is the largest group and includes about 60 per cent of the cases.

The third group (anaplastic, spindle, unripe, embryonal), as the various names given it imply, consists of tumors in which the histologic structure is that of a rapidly growing lesion made up of small cells, immature, with many mitoses, marked variation in staining qualities, relatively little stroma, and a tendency to invade lymphatics early. This group comprises about 20 per cent of the whole.

These percentages vary, but always about four-fifths of the lesions (80 per cent) are in the second and third groups. It is recognized that the cell most resistant to radiation in the three groups is the spinal, or fully developed adult type of squamous cell—that one which typifies Group 1 and represents only one-fifth (20 per cent) of our total lesions. We believe it is reasonable to assume that the high proportion of relatively radio-

sensitive lesions in the second and third histologic groups of cervix cancer accounts for the satisfactory response which so many of these cases make to radiation therapy, even when they are moderately advanced clinically.

We also wish again to emphasize, as other writers have done, that the most important factor in prognosis, regardless of the method of treatment employed or the histologic structure, is early diagnosis.

Since about 60 per cent of the cases are clinically unfavorable when recognized and as a rule appear with a large, infected, ulcerated lesion in the cervix, we have recently changed our routine treatment and all such cases receive X-ray treatment before the radium is given. In addition, they are instructed to take copious, warm antiseptic vaginal douches. Cases thus treated usually show marked improvement in the appearance of the primary lesion in ten days. It is then possible to apply radium to better advantage and with much less risk of a complicating pelvic infection.

Moreover, since September, 1928, we have omitted interstitial application of radium with needles or seeds from the first series of treatments. They are reserved for use three or more weeks after the primary series of treatments with X-ray and radium has been finished.

At that time any portion of the primary lesion which does not seem to be regressing satisfactorily can be treated to advantage with needles or seeds and with much less risk of infection or of an overdosage which may lead to the formation of fistulæ, or of spreading the disease by puncture, as the vitality of the cancer cells has been damaged by the preceding treatments.

It is interesting to note that we have found it necessary to use interstitial or buried radiation as a routine part of the after-treatment in only a rather small percentage of the cases.

TABLE I.—RADIATION DOSES DELIVERED BY CERVIX APPLICATORS AT POINTS INDICATED ON DIAGRAM (FIG. 2)

Bomb: 1,000 mc.-hr. in each position.
Tandem: 1,000 mc.-hr. from upper tube.
2,000 mc.-hr. from lower tube.
X-rays: 1 high voltage cycle, assumed to deliver 100 per cent erythema dose at each point within the area considered.

Point	Applicator	Per cent S.E.D.	Per cent S.E.D.	Per cent Total	Per cent Total
1	Bomb left	25		1	
	center	210	270	10	13
	right	35		2	
	Tandem upper	90	1690	4	82
	lower	1600		78	
	X-rays	100	100	5	5
	Total	2060	2060	100	100
2	Bomb left	20		—	
	center	100	150	2	2
	right	30		—	
	Tandem upper	140	5440	2	96
	lower	5300		94	
	X-rays	100	100	2	2
	Total	5690	5690	100	100
3	Bomb left	15		1	
	center	55	90	4	6
	right	20		1	
	Tandem upper	790	1320	53	88
	lower	530		35	
	X-rays	100	100	6	6
	Total	1510	1510	100	100
4	Bomb left	10		—	
	center	35	65	1	2
	right	20		1	
	Tandem upper	3140	3420	88	95
	lower	280		7	
	X-rays	100	100	3	3
	Total	3585	3585	100	100
5	Bomb left	10		2	
	center	25	50	4	9
	right	15		3	
	Tandem upper	310	440	53	75
	lower	130		22	
	X-rays	100	100	16	16
	Total	590	590	100	100
6	Bomb left	15		1	
	center	50	125	5	12
	right	60		6	
	Tandem upper	100	810	10	78
	lower	710		68	
	X-rays	100	100	10	10
	Total	1035	1035	100	100
7	Bomb left	15		1	
	center	55	120	5	10
	right	50		4	
	Tandem upper	120	980	10	82
	lower	860		72	
	X-rays	100	100	8	8
	Total	1205	1205	100	100

(Continued on next page)

(Table 1, continued)

Point	Applicator	Per cent S.E.D.	Per cent S.E.D.	Per cent Total	Per cent Total
8	Bomb left	5		—	
	center	40	80	4	8
	right	35		4	
	Tandem upper	340	790	35	80
	lower	450		45	
	X-rays	100	100	12	12
	Total	970	970	100	100
9	Bomb left	10		1	
	center	30	70	4	9
	right	30		4	
	Tandem upper	460	700	52	80
	lower	240		28	
	X-rays	100	100	11	11
	Total	870	870	100	100
10	Bomb left	10		1	
	center	25	175	3	23
	right	140		19	
	Tandem upper	90	460	12	62
	lower	370		50	
	X-rays	100	100	15	15
	Total	735	735	100	100
11	Bomb left	10		1	
	center	30	115	4	15
	right	75		10	
	Tandem upper	130	500	18	70
	lower	370		52	
	X-rays	100	100	15	15
	Total	715	715	100	100
12	Bomb left	10		2	
	center	30	85	5	14
	right	45		7	
	Tandem upper	185	425	30	70
	lower	240		40	
	X-rays	100	100	16	16
	Total	610	610	100	100
13	Bomb left	10		2	
	center	15	110	3	22
	right	85		17	
	Tandem upper	60	285	12	58
	lower	225		46	
	X-rays	100	100	20	20
	Total	495	495	100	100
14	Bomb left	5		1	
	center	15	75	3	15
	right	55		11	
	Tandem upper	85	310	18	64
	lower	225		46	
	X-rays	100	100	21	21
	Total	485	485	100	100
15	Bomb left	5		1	
	center	10	60	3	17
	right	45		13	
	Tandem upper	45	175	13	53
	lower	130		40	
	X-rays	100	100	30	30
	Total	335	335	100	100

TABLE II.—GOLD SEEDS NECESSARY TO DELIVER SPECIFIED DOSES IN GIVEN SPHERES

Sphere	Diam. cm.	Gold Seeds for 100 Per Cent S.E.D. mc.	Gold Seeds for 500 Per Cent S.E.D. mc.	Gold Seeds for 1,000 Per Cent S.E.D. mc.
A	2.0	1	5	10
B	3.0	2.2	11	22
C	4.0	4.4	22	44

Reviewing our cases treated with radium and low voltage X-ray in 1922, 1923, and 1924, and dividing them into two groups—*favorable* to include the early and borderline, and *unfavorable,* representing the advanced cases—there are 44.5 per cent of five-year clinical cures in the favorable group. This percentage will vary somewhat from year to year, but on the whole is fairly stationary and corresponds closely with other published reports in this country and in Europe.

I wish to express my thanks to Mrs. Edith Quimby, of the Department of Physics, who drew the diagrams and constructed the tables, and to Dr. Charles Lucas for his careful review of the records of 1922, 1923, and 1924.

HISTOLOGICAL STRUCTURE, CLINICAL GROUPING, AND PROGNOSIS OF CANCER OF THE UTERINE CERVIX AND THE BREAST[1]

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MANY of the most important facts about the prognosis of tumors can be learned only by the earnest cooperation of the surgeon, the radiologist, and the pathologist. The microscope determines the finer structure of the tumor, and enables it to be classified. From a certain type of structure, a certain behavior of growth may be predicted. But confirmation or refutation of the pathologist's prognosis must be verified from a study of the clinical course of the tumor. The pathologist sees only the tissue, the surgeon and radiologist observe the patient and thus know the eventual end-result. The clinician's most important contribution to medical science will be the publication of his final results. In carcinomata treated by surgery or radiology the questions to be studied are: Did a recurrence of the growth ensue? Was the recurrence due to the nature of the growth, or the inadequacy of the operation or radiation treatment or the dissemination of the cancerous disease?

It seems safe to say that if a tumor be completely removed by surgery it cannot and will not recur. Recurrences are, therefore, due to incomplete removal—a portion of the original tumor was left behind. If fringes of the tumor remain, it is equivalent to leaving some of the original tumor; if during operation some of the tumor cells be scattered over the wound, recurrences take place from their growth; if metastasis to regional lymph nodes or to viscera has taken place, the tumor continues to grow. The entire history of the primary, recurrent or secondary growths is, therefore, of one tumor substance, localized or distributed. Surgery, to be successful, must eradicate the entire tumor-bearing area.

Since the advent of radiology in the treatment of carcinoma clinical observations have had to be added concerning the study of the action of rays, the technic of the application of rays, and the end-results. Radiations act (1) by restraint of cell division without complete destruction of cell function; (2) by reactivation of the cell to mature from its undifferentiated condition to that state where the inhibitions or restraints of growth gradients are once more effective, and (3) by direct cell destruction. If radiations act homogeneously on the entire cell masses so that tumor cell division and differentiation become normal or cell destruction is complete, then the growth will not recur. Should the radiosensitivity of the tumor cell be of a low degree or the radiations be applied faultily, then recurrences will take place, just as incomplete surgical removal will cause continuation of the growth.

In recent years numerous reports have appeared in the medical literature dealing with investigations into the correlations existing between the histological structure, the clinical extent of the growth, the surgical and radiological treatment, and the prognosis of malignant tumors. The most reliable information in regard to the prognosis of malignant tumors is at present obtained by an evaluation of the histological structure and a consideration of the clinical extent. These

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two factors have been taken into account in the work presented in this paper.

THE HISTOLOGICAL MALIGNANCY

For the determination of the histological malignancy twenty factors characterizing the degree of differentiation and anaplasia of the tumor parenchyma and the antiblastic condition of the stroma were evaluated according to the method elaborated by one of us (Hueper). The list of these factors composing the "histological malignogram" (Hueper) and showing the numerical values given is as follows:

I.	Special cellular and structural characteristics of carcinoma		Valued 5–20
1.	Special cell type of carcinoma	valued	1–4
2.	Nucleo-cytoplasmic coefficient	"	1–4
3.	Number of "pencil-cells"	"	1–4
4.	Infiltrative growth of carcinoma	"	1–4
5.	General type of carcinoma (parenchyma-stroma relation)	"	1–4
II.	Characteristics of cytoplasm		Valued 5–20
6.	Irregularity in size of cells	"	1–4
7.	Irregularity in shape of cells	"	1–4
8.	Distinctness in outline of cells	"	1–4
9.	Chromatism of cytoplasm	"	1–4
10.	Functional activity of cells	"	1–4
III.	Characteristics of nuclei		Valued 6–24
11.	Irregularity in size of nuclei	"	1–4
12.	Irregularity in shape of nuclei	"	1–4
13.	Chromatism of nuclei	"	1–4
14.	Hyperchromatism of nuclei	"	1–4
15.	Number of mitoses and prophases	"	1–4
16.	Irregularity of mitoses	"	1–4
IV.	Characteristics of stroma		Valued 4–16
17.	Character of stroma	"	1–4
18.	Vascularity of stroma	"	1–4
19.	Type of cellular infiltration	"	1–4
20.	Amount of cellular infiltration	"	1–4

DEFINITIONS OF FACTORS AND TECHNIC OF EVALUATION

1. *Special cell type of carcinoma.* After a general classification of the carcinomata into two main groups, the primary solid carcinomata and the glandular or adenocarcinomata, the tumors are subdivided into four subgroups according to their general structure and the maturity of the predominant cell type. Carcinomata of Sub-group 1 are evaluated with 1 point, those of Sub-group 2 with 2 points, those of Sub-group 3 with 3 points, and those of Sub-group 4 with 4 points.

A. Glandular carcinomata
 1. Malignant adenoma
 2. Papillary and gelatinous adenocarcinoma
 3. Adenocarcinoma simplex
 4. Solid adenocarcinoma

B. Primary solid carcinoma
 1. Spinous-cell carcinoma, with cornifications
 2. Spinous-cell carcinoma, without cornifications
 3. Round-cell carcinoma
 4. Spindle-cell carcinoma

2. *Nucleo-cytoplasmic coefficient.* The relative number of those carcinoma cells which show a large nucleus surrounded by a small amount of cytoplasm is estimated. If 10 per cent or less of such cells are found among the tumor cells, 1 point is counted. Their presence in from 10–20 per cent is evaluated with 2 points, in from 20–30 per cent with 3 points, and in more than 30 per cent with 4 points.

3. *Number of "pencil-cells."* "Pencil-cells," which are slender cells with dark stained nuclei invading and destroying the carcinoma cells, are counted with 1 point when they are very numerous. Two points

are evaluated when they are present in moderate number, 3 points when they are scanty, and 4 points when they are completely absent.

4. *Infiltrative growth of cells.* The presence of well defined outlines in the majority of the carcinomatous cell nests is evaluated with 1 point, diffuse invasion present in from 25–50 per cent of the cell strands with 2 points, in from 50–75 per cent with 3 points, and in more than 75 per cent with 4 points.

5. *General type of carcinoma.* If 75 per cent or more of the carcinoma is composed of parenchyma and 25 per cent or less of stroma, 4 points are counted; if from 50–75 per cent is parenchyma and from 25–50 per cent is stroma, 3 points are evaluated; if from 25–50 per cent is parenchyma and from 50–75 per cent is stroma, 2 points are noted, and if 25 per cent or less is parenchyma and 75 per cent or more is stroma, 1 point is counted.

6 and 7. *Irregularity in size and shape of cells.* The average size and shape of the tumor cells are studied. Deviations from this size and shape, respectively, in from 40–50 per cent of the cells are evaluated with 4 points, in from 30–40 per cent with 3 points, in from 20–30 per cent with 2 points, and in 20 per cent or less with 1 point.

8. *Distinctness in outline of cells.* Distinct outlines present in 75 per cent or more of the tumor cells are evaluated with 1 point, in from 50–75 per cent with 2 points, in from 25–50 per cent with 3 points, and in less than 25 per cent with 4 points.

9. *Chromatism of cytoplasm.* If the majority of the carcinoma cells have an almost unstained cytoplasm, while the connective tissue cells are distinctly pink stained, 4 points are counted. If the cytoplasm is only slightly pink stained, 3 points are evaluated; a moderately pink stained cytoplasm is counted 2 points and a distinctly pink stained cytoplasm 1 point.

10. *Functional activity of cells.* Granules of keratin and droplets of mucus, respectively, or the presence of vacuoles in tumor cells which do not show signs of degeneration, are regarded as evidence of functional activity. If these products are present in less than 10 per cent of the tumor cells, 4 points are evaluated; if they are seen in 10–20 per cent of the tumor cells, 3 points are counted; if present in 20–30 per cent, 2 points are noted, and if observed in more than 30 per cent of the cells, 4 points are marked.

11 and 12. *Irregularity in size and shape of the nuclei.* The same viewpoints and percentages are used in the evaluation of this factor as described for Factors Nos. 6 and 7.

13. *Chromatism of nuclei.* Four points are evaluated if the majority of the nuclei is almost as deeply stained as those of lymphocytes, 3 points if they are somewhat paler, 2 points if they are considerably paler, and 1 point if they are very pale compared with the nuclei of fibroblasts.

14. *Hyperchromatism of nuclei.* If 20 per cent or more of the nuclei are as dark as those of lymphocytes, the factor is evaluated with 4 points; if from 15–20 per cent are hyperchromatic, 3 points are counted; if from 10–15 per cent, 2 points, and if such nuclei are present in less than 10 per cent, 1 point is counted.

15. *Number of mitoses and prophases.* The mitotic figures and prophases in 10 fields are counted with the help of an oil immersion, giving a magnification of 1,050 times. Twenty or more mitoses and prophases receive 4 points, 15–19 are noted with 3 points, 10–14 with 2 points, and 0–9 with 1 point.

16. *Irregularity of mitoses.* Pathological types of mitoses present in less than 10 per cent of the mitotic figures are counted with 1 point, in from 10–20 per cent with 2 points, in from 20–30 per cent with 3 points, and in more than 30 per cent with 4 points.

17. *Character of stroma.* A very loose, edematous connective tissue stroma is count-

ed 4 points, a moderately loose one 3 points, a fibrous one 2 points, and a fibrous one with extensive hyalinizations 1 point.

18. *Vascularity of stroma.* A highly vascular stroma is evaluated with 4 points, a moderately vascular one with 3 points, a slightly vascular one with 2 points, and one with very scanty vessels with 1 point.

19. *Type of cellular infiltration of stroma.* A predominantly eosinophilic infiltration of the stroma is evaluated with 1 point, one mainly composed of lymphocytes mixed with some eosinophiles with 2 points, one consisting of lymphocytes, plasma cells, and scanty neutrophilic leukocytes with 3 points, and one predominantly composed of neutrophilic leukocytes with 4 points.

20. *Amount of cellular infiltration of stroma.* A dense infiltration of the stroma is evaluated with 1 point, a moderately dense one with 2 points, a slight one with 3 points, and a very scanty one with 4 points.

The numerical values obtained by this method are added and the sum resulting is called "histological malignancy index" (Hueper), which represents the numerical expression of the potential malignancy of a given tumor as evidenced by its histological structure. The numerical range of the "histological malignancy index" is between 20 and 80. The evaluations show that the malignancy increases with an increase in the value of the malignancy index.

THE DETERMINATION OF THE CLINICAL EXTENT OF THE GROWTH

The clinical extent, the second factor, which has an important effect upon the prognosis of malignant tumors, is represented in the clinical grouping of carcinomata of the uterine cervix and of the breast as elaborated by one of us (Schmitz). Its estimation is based on physical findings. The carcinomata are divided into primary, secondary, and recurrent. The factors which determine the clinical grading of the primary carcinomata of the uterine cervix are:

Group P1 signifies a cancer growth clearly localized within the cervix. It should be about 1 cm. in diameter. The size is determined by palpation and inspection. The genital organs are movable within normal limits.

Group P2 indicates a growth which has extended to the periphery of the cervix in a longitudinal or transverse direction. The uterus has an impeded movability due to a dough-like consistency and decreased elasticity of the paracervical tissues.

Group P3 means that either one or both parametria or the regional lymph nodes have been invaded, a fact which is elicited by rectal examination. The tumor mass is movable, though elasticity of the tissues is lost.

Group P4 includes the carcinomata with absolute fixation, vaginal, vesical, or rectal extension, distant secondary growths, advanced cachexia.

The primary carcinomata of the breast are classified according to similar considerations:

Group P1 represents a clearly localized, freely movable growth which is not adherent to skin or pectoral fascia and which has not produced any metastases in the regional lymph nodes, as evidenced by pre-operative palpation and corroborated by post-operative histological examination.

Group P2 signifies a single node which is still freely movable but which has produced metastases either in the breast or lower axillary lymph nodes, and primary multiple tumors as observed after chronic cystic mastitis.

Group P3 includes those tumors which have become adherent to the skin or fascia or both. There may be multiplicity in the breast and metastases in the lower and up-

per axillary lymph nodes. The primary and metastatic tumors are movable, though movability is impeded.

Group P4 means that the tumor has either permeated the entire skin with ulceration, or has become fixed to the chest wall, or has produced fixed metastases in the upper axillary lymph nodes, or has invaded the supraclavicular lymph nodes, or caused multiple invasions of the skin. The other breast also may be involved. Metastases may have been produced in distant organs. The primary and metastatic growths are firmly fixed to the skin or chest wall or axillary structures.

The characteristics of the groups in the recurrent carcinomata are: Group R1 contains the local but freely movable, clearly localized recurrences; Group R2 the regional, freely movable recurrences; Group R3 the local and regional movable recurrences, and Group R4 the local or regional recurrences, with fixation or secondary invasion in distant organs (supraclavicular lymph node, bone, etc.).

The clinical grouping has a threefold purpose. It indicates those cases which invariably have a poor prognosis (Group 4). It furnishes, furthermore, the correct indications for treatment and is an aid in establishing exact statistics to determine the therapeutic efficacy of either operation or radiation. Table I comprises the cases of primary carcinomata of the cervix and the breast admitted and treated up to the end of 1924 in the clinic of Schmitz.

RESULTS OF STUDY

Malignancy indices were determined from 225 cases of carcinoma of the uterine cervix and 136 cases of carcinoma of the breast. The patients entered Mercy Hospital in the years 1922–1926.

MALIGNANCY INDEX AND END-RESULTS

The prognostic value of the histological malignancy index was tested against the end-results obtained. The malignancy indices were first determined and they then were entered in the clinical histories. Thus the work of the pathologist could not be influenced by the end-results obtained. The following classification of the end-results was made:

Clinical End-result 1 means that the patient was free from symptoms and showed anatomical healing three years after termination of the treatment.

End-result 2 indicates death during the third year.

End-result 3 means death during the second year.

End-result 4, death during the first year after treatment. Cases of Clinical Group 4 are eliminated from the following compilation as they almost always have a poor prognosis, regardless of the histological malignancy index and the treatment used. The end-results were known in 100 cases of cervical carcinoma and 71 cases of carcinoma of the breast.

To test the histological malignancy index

TABLE I

FIVE-YEAR GOOD END-RESULTS IN PRIMARY CARCINOMATA

Group	CERVIX			BREAST		
	Number	Well	Per cent	Number	Well	Per cent
P 1	23	18	78.27	13	9	69.23
P 2	48	20	41.68	29	15	51.72
P 3	161	20	12.42	34	4	11.77
P 4	100	0	0	31	1	3.23
Total	332	58	17.50	107	29	27.10

Operability, *i.e.*, Groups 1 and 2, is *21.09* per cent. Relative curability in 71 operable cases was 38, or 53.52 per cent, with the use of radium and X-rays.

Operability, *i.e.*, Groups 1 and 2, is *39.25* per cent. Relative curability in 42 operable cases was 24, or 50.72 per cent, with operation and post-operative X-ray.

against the good End-results 1 the values were divided into four even parts. The average malignancy index value of cervix carcinomata is 55.76 and for breast carcinomata 56.04; hence 56 was taken as the average value. Each malignancy index group has a range of 12 points, that is: Group 1, from 32 to 44; Group 2, from 45 to 56; Group 3, from 57 to 68, and Group 4, from 69 to 80.

TABLE III

AVERAGE MALIGNANCY INDEX

	Cervix	Breast
End-result 1	52.45	54.48
End-result 2	53.00	59.11
End-result 3	60.00	58.70
End-result 4	61.00	61.35

It is evident from Table IV (page 229) that carcinomata of the breast have on the average a somewhat higher histological malignancy than those of the uterine cervix, as carcinomata of the breast are less frequent than those of the cervix in the first two malignancy groups.

TABLE II

	Breast	Cervix	Breast	Cervix	Breast	Cervix	Breast	Cervix
Malignancy Index	32–44		45–56		57–68		69–80	
Number of cases	2	5	24	28	24	27	3	2
Number of End-result 1	2	4	16	17	9	7	0	0
Percentage of End-result 1	100	80	66	50.7	37.5	25.8	0	0

The practical significance of the histological malignancy index is strikingly demonstrated by the agreement of the figures given above. The general average malignancy index of the 136 breast carcinomata is 56.04 and that of the 225 carcinomata of the uterine cervix is 55.76. The average malignancy index of 28 breast carcinomata with End-result 1 is 54.48 (range 40–64) and of 31 cervical carcinomata 52.45 (range 40–64). Nine of these 28 breast cancers (or 30.11 per cent) have a malignancy index above the general average index of 56.04, and 8 of the 31 cervical cancers (or 25.81 per cent) are above the general average of cervical carcinomata of 55.76. The average malignancy index of 26 breast carcinomata with End-result 2–4 is 59.88, while that of 40 cases of cervical cancers with End-result 2–4 is 59.39. Nineteen of these 26 cases of breast cancer (or 73.07 per cent) have a malignancy index above the general average malignancy index, while 40 cases (or 58 per cent) of the 69 cervical carcinomata have a malignancy index above their general average malignancy index.

Table III shows that the malignancy index has a tendency to be higher in cases which take a rapid course than in those with a slow course.

TABLE V

SPECIAL CELL TYPE AND MALIGNANCY INDEX

Cell Type	Cervix	Breast
Cell type 1	45.67 (range 38–54)	40.5 (range 40–41)
Number of cases	9	2
Cell type 2	48.62 (range 32–68)	51.75 (range 44–62)
Number of cases	61	16
Cell type 3	54.65 (range 37–70)	54.70 (range 47–70)
Number of cases	106	43
Cell type 4	60.76 (range 41–75)	56.41 (range 42–72)
Number of cases	49	91

Table V (above) permits the conclusions that the special cell type or the degree of differentiation runs to a certain extent parallel with the degree of histological malignancy in the respective types. But it is also apparent that the evaluation of a carcinoma by the method of the malignancy index gives far more reliable results than the grading of carcinomata on the basis of cell type or degree of differentiation. The differences between the average malignancy indices of the different cell types are not marked enough to indicate definite differences in malignancy and prognosis for most of the groups.

TABLE IV

DISTRIBUTION OF CARCINOMATA IN THE MALIGNANCY GROUP

	Cervix	Breast
Group 1 (32-44)	16.82 per cent (38 cases)	2.94 per cent (4 cases)
Group 2 (45-56)	42.92 per cent (97 cases)	36.76 per cent (50 cases)
Group 3 (57-68)	36.72 per cent (82 cases)	56.62 per cent (77 cases)
Group 4 (69-80)	3.54 per cent (8 cases)	3.68 per cent (5 cases)

GENERAL TYPE OF CARCINOMA AND MALIGNANCY INDEX

The relation existing between the general type, the malignancy index, and the prognosis of a carcinoma was studied to ascertain if highly cellular tumors are more malignant than oligocellular (zellarm). For this purpose the average malignancy indices of the carcinomata of the General type 4 were compared with those of the General type 1. cers of the breast the stroma contributed on the average 12.00 points to the malignancy index; in medullary cancers of the cervix the stroma added 11.28 points, while in scirrhous carcinomata of these organs only 9.67 points (breast) and 9.9 points (cervix), respectively, were contributed to the malignancy index by the stroma. The differences are 2.33 points for the breast and 1.38 points for the cervix. If these observations are taken into account, it becomes evident that

TABLE VI

AVERAGE MALIGNANCY INDEX

	Cervix	Breast
General Type 4	54.11	57.44
Number of cases	120 (53.33% of total number)	65 (47.06% of total number)
General Type 1	52.30	55.16
Number of cases	20 (8.89% of total number)	19 (13.97% of total number)

One may state that, in general, cellular or medullary growths are more likely to have a loose, vascular stroma, with a more or less marked round-cell infiltration, while the rather oligocellular or fibrous or scirrhous cancers show usually a fibrous or hyalinized stroma, with few vessels and scant round-cell infiltration. Deviations from this rule occur, but have not been taken into consideration.

The numerical difference between cancers of General type 4 and General type 1 is three points, if all other factors are equal. As is apparent from Table VI, the actual difference is less than anticipated (1.81 and 2.28). Moreover, one has to consider that the antiblastic status of medullary cancers is usually less marked than that of scirrhous ones. This statement is substantiated by the following figures: In medullary cancers the parenchyma of scirrhous cancers is more malignant on the average than that of medullary tumors. The blastic qualities of the parenchyma of a scirrhous cancer of the breast surpass by 3.05 points (0.72 plus 2.53) and those of the cervix by 2.58 points (1.81 plus 1.39) those of the medullary tumors of the respective organs.

CONCLUSIONS

1. A description of the determination of the histological malignancy index and the classification of the clinical groups based on the extent of the carcinoma has been given.

2. The histological malignancy indices were determined in 225 cases of carcinomata of the uterine cervix and 136 cases of carcinomata of the breast. The end-results were known in 100 cases of cervical and 71 cases of mammary cancers.

TABLE VII

CARCINOMATA OF THE UTERINE CERVIX WITH KNOWN END-RESULTS

Journal number	1	3	4	5	6	7	8	9	10	11	14	15	16	17	21	22	24	25	29	30
Malignancy index	69	70	54	57	55	62	54	63	65	64	67	47	61	51	52	53	56	67	53	58
Clinical group	3	R3	R3	3	3	4	3	4	3	2	R3	2	Ad R1	Ad R3	R4	2	3	2	3	Ad 3
End-result	4	4	3	3	1*	2	3	4	2	4	3	1	1*	4	4	2	3	4	1	2
Journal number	31	33	35	37	40	41	45	46	47	48	49	51	52	53	55	57	58	61	62	63
Malignancy index	66	52	54	37	64	49	62	47	49	64	40	75	64	62	61	52	55	50	55	38
Clinical group	R3	R4	4	4	Ad R4	3	3	3	Ad 3	3	3	Ad 3	3	4	4	3	4	3	2	R3
End-result	3	1	3	4	4	1*	3	1*	1*	3	1*	3	2	4	4	1	4	1*	1	2
Journal number	65	66	68	70	71	72	73	74	76	77	78	79	83	85	86	87	89	90	92	93
Malignancy index	72	47	45	56	47	56	53	64	62	63	57	74	41	61	57	41	66	44	54	44
Clinical group	3	Ad 3	4	3	Ad 2	2	3	3	4	3	3	4	3	4	4	Ad 4	4	3	4	2
End-result	3	1	3	4	3	1	3	1*	3	3	1	4	1	4	1	4	4	1	3	1
Journal number	95	96	98	99	100	107	111	118	121	122	131	149	175	176	177	178	179	180	181	182
Malignancy index	54	45	49	52	45	46	68	60	49	55	63	59	55	62	45	64	65	39	67	54
Clinical group	4	Ad 1	R4	Ad 4	R3	1	3	4	3	4	1	2	Ad 1	Ad R3	4	3	3	4	4	3
End-result	1	1	3	3	3	1	2	4	2	4	1	4	1	3	4	3	3	2	2	1
Journal number	184	185	186	187	189	190	192	194	195	198	199	201	202	205	206	208	210	217	218	222
Malignancy index	62	61	57	62	66	60	49	55	48	53	52	60	64	61	47	45	49	59	50	48
Clinical group	2	Ad 2	Ad 3	Ad 4	Ad 4	4	Ad 4	Ad 2	Ad R3	4	2	4	3	3	4	4	4	3	R3	4
End-result	1	1	2	4	4	3	2	4	2	4	1	4	1	4	4	2	4	4	1	4

TABLE VIII

CARCINOMATA OF THE BREAST WITH KNOWN END-RESULTS

Journal number	1	2	3	6	7	8	9	10	12	13	15	17	18	20	21	22	24	26	27	28	29	30	31	32	33
Malignancy index	67	64	60	69	59	52	66	57	58	47	49	66	62	52	51	50	51	61	64	55	59	61	64	72	59
Clinical group	R4	R4	P4	P4	P3	P3	P3	R4	P4	P2	P2	R4	R3	P2	P4	P1	R2	R4	P4	P3	P3	P2	R4	P4	R4
End-result	3**	4**	2**	3**	1**	1**	4**	3**	3**	1**	2**	3**	2**	1**	3**	1**	1**	3**	4**	1**	1**	1**	4**	4**	3**
Journal number	34	36	37	38	39	42	43		46	47	49	50	52	53	56	60	65	69	74	77	78	80	82	84	85
Malignancy index	56	57	60	51	52	65	70		69	58	52	58	46	62	49	66	40	63	45	57	57	49	54	64	60
Clinical group	R4	P2	P3	P3	P3	P2	P3		P3	R	P3	P4	R4	R2	P2	P3	P1	P	P3	P4	P3	P4	P2	P2	P4
End-result	4**	1**	1**	1**	1**	3	3		4	3**	2	4	3	3	1	2	1	1	1	3	2	2**	1	1	3
Journal number		87	88	93	95	97	101	104	105	106	107	108	109	110	111	114	116	117	119	122	123	125	126	128	131
Malignancy index		50	58	50	51	51	48	44	59	49	57	45	50	47	55	57	63	63	58	61	67	51	61	59	69
Clinical group		P2	P2	P3	P2	P2	P3	P3	P3	P3	P3	P3	P2	P1	P3	P3	R1	P3	P3	P3	P1	P1	P3	R1	R3
End-result		4	1**	1	1	1	1	1	2	3	3	3	1	1	3	1	3	3	1	4	2	1	1	1	4

NOTE: Cervical carcinomata with an asterisk represent five-year cures. Breast carcinomata with a double asterisk indicate post-operative roentgen treatment.

3. The prognostic value of the histological malignancy index was tested against the end-results obtained. The result is that the malignancy increases with an increase in the value of the malignancy index. In Malignancy Group 1 the good end-results were 100 per cent in breast carcinomata and 80 per cent in cervix carcinomata. In Malignancy Group 2 the good end-results were 60 per cent in breast cancers and 50.7 per cent in cervix cancers. In Malignancy Group 3 the good end-results were 37.5 and 25.8 per cent, respectively, while in Malignancy Group 4 good end-results were not obtained in a single instance.

4. The clinical grouping gave relatively similar values. The five-year good end-results in Clinical Group 1 were 69.23 per cent in breast cancers and 78.27 per cent in cervical cancers. In Clinical Group 2 they were 51.72 and 31.68 per cent, respectively; in Clinical Group 3 they were 11.77 and 12.42 per cent, respectively, and in Clinical Group 4 they were 3.23 per cent and 0, respectively.

5. The study of the degree of histological malignancy and the extent of the growth gives valuable data in the prognosis and treatment of carcinomata of the breast and uterine cervix.

Thanks are due to Dr. W. Barnes, Dr. C. Connor, Dr. J. Golden, Dr. M. McGuire, Dr. L. D. Moorhead, Dr. G. Morgan, and Dr. T. Sawyer for their kind co-operation in this work by supplying us with the histories and end-results of their cases of breast carcinomata.

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RADIUM AND X-RAY THERAPY AS PALLIATIVE MEASURES IN THE TREATMENT OF RECTAL CANCER[1]

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EXCLUSIVE of the stomach and oral cavity, approximately 60 per cent of the remaining intestinal cancers are indigenous to the rectum. Rectal cancers are notoriously difficult to cure because 40 to 50 per cent are inoperable when first seen by the surgeon; the rectum is in daily use; the tumor mass is not easily accessible; the degree of dissemination cannot be estimated by physical examination; the complete removal of all cancer-bearing tissue is a difficult operative feat accompanied by a high immediate mortality.

THE PATHOLOGY OF RECTAL CARCINOMAS

Epithelioma or squamous-cell carcinoma of the anus is uncommon, aggregating only 3 to 4 per cent of all rectal cancers. Its site of predilection is at the mucocutaneous junction in the mid-line, anteriorly. It forms a nodular, warty, flattened growth which tends to ulcerate and involve the rectum proper. Its radiosensitivity corresponds with that of the lip and the buccal mucosa; the most satisfactory plan of treatment is irradiation by the interstitial deposition of small metal-filtered radon implants, known as gold or platinum seeds.

The remaining cancers of this region are adenocarcinomas, which are also the most frequent tumors. The symptomatology, growth tendencies, and pathology of these differ according to their location in the rectal canal. At the rectosigmoidal junction the tumor early encircles the bowel to form an annular stricture. The majority of carcinomas of the rectal ampulla begin on the posterior wall. The four common types of adenocarcinomas of this region are:

(1) The papillary carcinoma.

(2) The malignant adenoma, or adenoma destruens.

(3) The colloid, or gelatinous carcinoma.

(4) The scirrhus or fibrocarcinoma.

The papilliferous, or papillomatous, carcinoma resembles the benign papilloma somewhat, except for the invasive nature of its base. This tumor may be frankly malignant from its onset, or it may be a malignant degeneracy of the benign papilloma. Its growth energy is expended largely by evertent or surface proliferation, producing a bulky exuberant tumor, before the bowel wall is infiltrated. This cancer is readily amenable to surgical extirpation; when radium therapy is to be employed, the papilliferous fronds are removed by surgical endothermy and gold or platinum filtered radon seeds are implanted into the base of the cancer.

The scirrhus or fibrocarcinoma is a peculiar type of rectal carcinoma, exhibiting desmoplastic tendencies, in which the atypical cancer cells are growing diffusely and are nestled away among wide strands of new connective tissue. This cancer is markedly radioresistant.

The colloid or gelatinous carcinoma is a degenerative type of adenocarcinoma. It usually forms a bulky, massive growth in which gelatinous or mucoid material replaces the tumor tissue. It likewise does not respond well to radiation therapy.

Adenoma destruens is the most common type of cancer of the rectum. It may appear early as a cancerous plaque, later forming a malignant ulcer due to the necrosis

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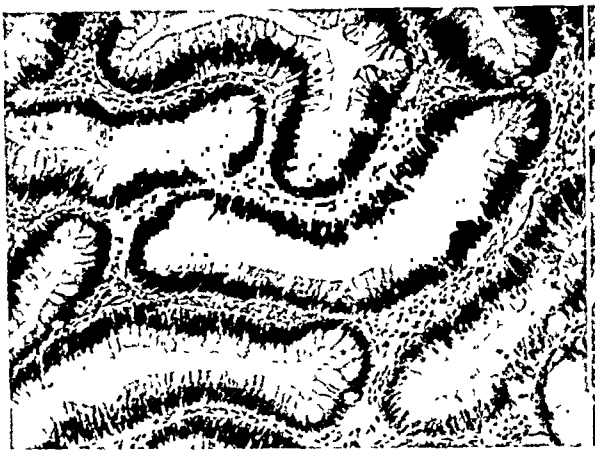


Fig. 1. Rectal cancer (adenomalignum), Grade I, radioresistant, very low degree of malignancy.

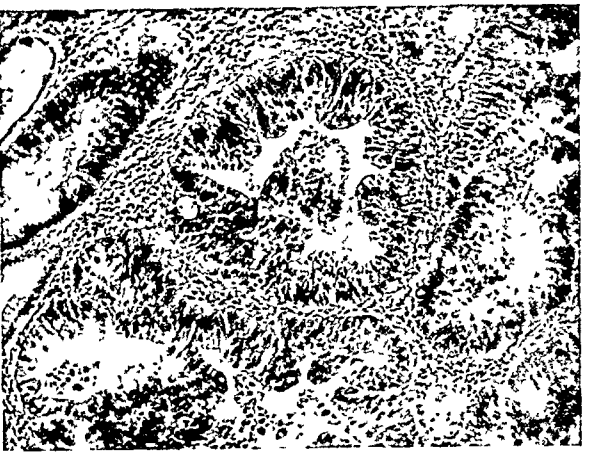


Fig. 2. Adenoma destruens, Grade II, radioresistant.

of the overlying surface. The tubules and their component cells may be quite similar to normal tissue in some instances, insomuch as there is much variation in the histological character and malignancy of these tumors. Only too frequently they penetrate the muscularis mucosa, early and deeply, with the formation of solid, medullary or cord-like masses of cells or irregularly arranged acini within the submucosa. Secondary infection and trauma cause ulceration, which hastens the dissemination of the tumor. The malignant ulcer is crater-like, with indurated elevated edges, occurring for the most part in the lower part of the rectum and at times encroaching on the sphincter.

With consideration of the fundamental principle of cell-differentiation, Rankin and Broders (9) have formulated a histologic classification of the grades of malignancy found in rectal carcinomas. Their conclusions have been substantiated by the studies of Stewart and Spies (12) on biopsy specimens of rectal cancers. These authors and others use four degrees of differentiation: Group or Grade I, Highly differentiated, adult-cell, radioresistant adenocarcinomas; Grade II, less differentiation and slight radioresistance in these adenocarcinomas; Grade III, still less differentiation but slight radiosensitivity in these adenocarcinomas; Grade IV, differentiated, anaplastic, cellular radiosensitive adenocarcinomas.

THE DISSEMINATION OF RECTAL CANCER

A knowledge of the lymphatic drainage of the rectum is essential in order to place properly interstitial foci of radon and thereby anticipate and prevent the dissemination of rectal cancers. Miles (7) has recently classified the lymphatic supply of the rectum in a comprehensive manner; his arrangement is herein given:

1. The intramural lymphatics in the wall of the rectum form two plexuses which communicate freely by channels radially arranged. These two plexuses are arranged in the following manner:

(a) The submucous plexus consists of a network of lymphatics in the ampullary portion of the rectum, which communicates with the lymphatics of the pelvic colon and of the anal canal.

(b) The intermuscular plexus is continuous with the lymphatics of the pelvic colon and those which supply the external sphincter.

2. The intermediary rectal lymphatics



Fig. 3. Adenocarcinoma of rectum, Grade III, radioresistant.

consist of a subserous network beneath the peritoneum of the upper part of the rectum, and a lower communicating lymph space, or cistern, situated between the external muscular coat and the perirectal fat in that part of the rectum not invested with peritoneum.

3. The extramural lymphatics of the rectum spread in three directions: inferiorly, laterally, and superiorly.

(a) Inferior efferent lymphatics.—These lymphatics supply the peri-anal skin, the external sphincter muscle, and the ischiorectal fat. The anal integument has an abundant lymphatic network, from which three to five vessels pass on either side to the inguinal region and end in the medial superficial inguinal nodes.

(b) Lateral efferent lymphatics.—These extend outward between the levator ani muscles and the pelvic fascia. The peritoneum is in close relationship with the lymphatics of the pelvic fascia. Other efferents leave to drain into the internal iliac glands. Anastomoses occur with the lymph vessels of the uterus, vagina, bladder, broad ligament, or prostate.

(c) Superior efferent lymphatics.—This is the most important zone for the spread of rectal cancer. These lymphatics accompany the superior hemorrhoidal veins and enter the lowermost mesocolic (retrorectal) glands. They accompany the inferior mesenteric vein, to empty into a group of glands called the aortic or median lumbar glands.

These are the three ways in which cancer of the anorectal region is disseminated, *viz.:* direct extension or by continuity; lymph spread by permeation of the lymphatics or lymphatic embolism, and metastases by the blood-vascular system. Direct extension is the first process to be initiated; lymphatic spread is next in time and frequency and is of the most surgical importance; embolic metastasis by the blood stream occurs late in the history of the disease, but there are instances where distant metastases have occurred with a quite small primary growth.

Local extension is the result of the infiltrative invasive tendencies of the rectal cancer. This converts a movable cancer nodule in the mucous coat into a fixed growth, inseparably fused with the muscular layer. Although the advancement is in all directions, the most rapid spread is transversely, particularly at the rectosigmoidal junction. The microscopic growing edge burrows freely under the mucous membrane, a fact of which the radiologist must be cognizant, that he may place some radon seeds well beyond the palpable border of the tumor.

The lymph spread of cancer may follow any of the lymphatic pathways previously described. The submucous lymphatic plexus is composed of lymphatic vessels which encircle the bowel, whereas the intermuscular plexus runs longitudinally. It is extremely likely that this is one reason for the tendency of cancer to encircle the bowel wall, because little groups of cancer cells can be discerned at some distance from the primary growth and later form submucous nodules which surround the periphery of the tumor. In cancer of the anus, both the rectal and inguinal glands may be involved as well

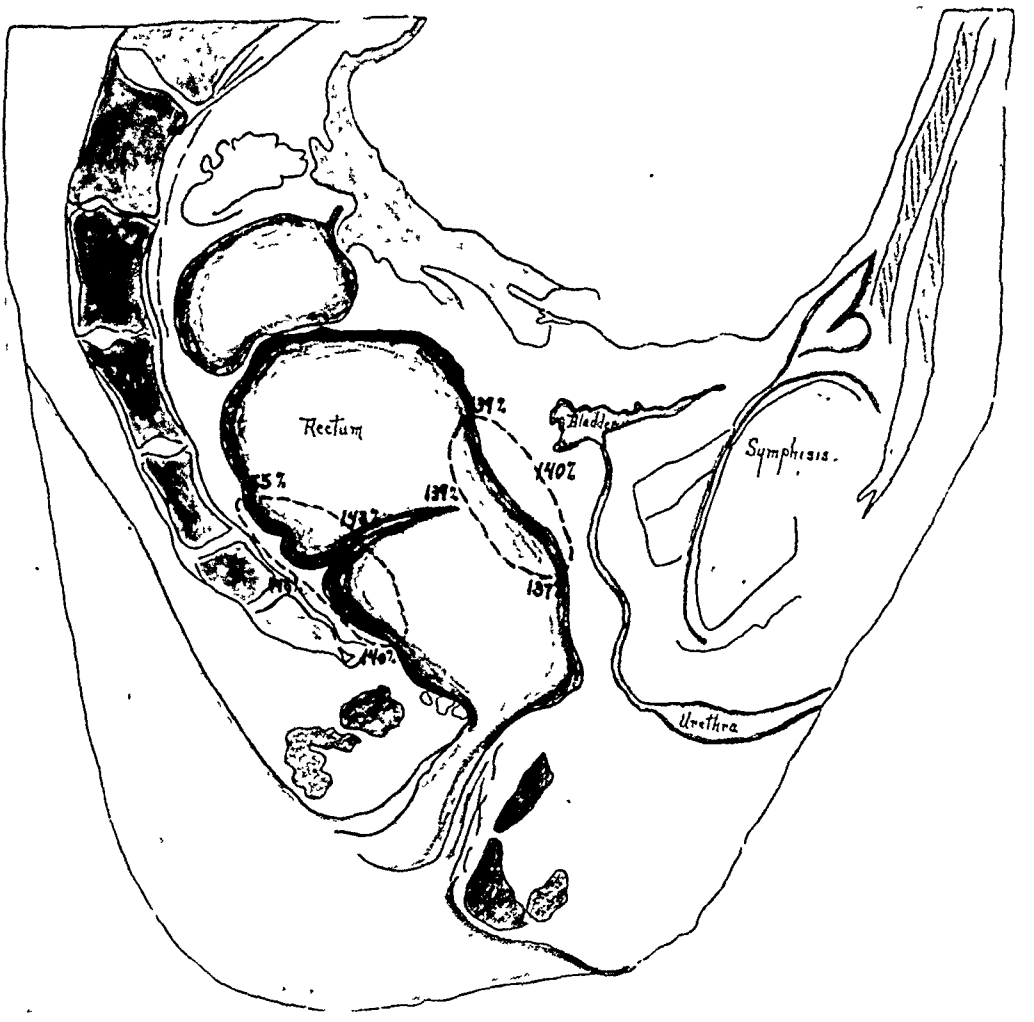


Fig. 4. Tissue dosage estimation in rectal cancer. Small patient: six portals (two anterior, two posterior, and two lateral), high voltage X-radiation.

as the external sphincter muscle, the peri-anal skin, and the ischiorectal space. This lymphatic spread involves the same viscera as in direct extension, but at a much earlier date.

The practical application of this knowledge to the treatment of rectal cancer depends on the proper placement of radioactive foci—gold or platinum radon seeds superficially in the submucosa of the rectum for the same segment of rectum in which the cancer occurs, in order to care for the circular spread by the submucous lymphatic plexus; gold or platinum radon seeds in the wall above and below the cancer, in order to care for the longitudinal spread by the intermuscular lymphatic plexus; the placement of similar seeds or radium element needles in the peri-anal region, the external sphincter muscle, and in the ischiorectal fossa, the treatments to be given supplementary to the direct treatment of the tumor mass.

RADIATION THERAPY OF RECTAL CANCER

What rectal cancers shall be treated by irradiation? Will irradiation alone suffice for the treatment of operable cancers? The radiologist rarely has the opportunity to treat a rectal cancer in its operable stage; usually he must be content with his efforts

to treat inoperable carcinomas and carcinomas recurrent after operation. Under these conditions, the physical agents, namely, X-ray and radium, are decidedly at a disadvantage if statistical analyses for curative results are made, unless one considers the stage and extent of the disease at the time of the initial radiation treatment.

An early biopsy, with histologic grading of the tumor, is of aid in the determination of the radiation procedure. If the cancer is deemed operable and histologically it is graded I, then surgery alone is the procedure of choice because radiation is wasted on such a tumor. Carcinomas graded II, III, and particularly IV, which are considered operable, should receive at least one pre-operative cycle of X-irradiation about the pelvis. No surgeon, however prejudiced he may be in favor of surgery over radiation therapy, should ever operate on a patient with rectal cancer until a biopsy has been done, with histologic grading of the cancer. The cellular, anaplastic, undifferentiated rectal cancers of Grade IV are not only the most malignant rectal tumors but they are also easily disseminated by the surgeon's knife; fortunately they are radiosensitive tumors, so we are justified in considering heavy external irradiation as an imperative and life-saving preliminary measure in the treatment of these particular cancers. Even if cure by external irradiation cannot be effected, the palpable diminution in the size of the tumor, the increased ease of operation, the amount of growth restraint, and the inactive state of this type of cancer as affected by external irradiation, favor the success of the later operative removal. The radical excision of the rectum should be delayed for at least four weeks after the pre-operative external irradiation.

What can the surgeon do for patients with inoperable rectal cancer? The answer is, "Nothing but colostomy." In inoperable cases are radium and X-ray treatments palliative measures? Do they relieve suffering? Do they prolong life? The answer is in the affirmative. What determines the inoperability of a rectal cancer? I would answer: "The immovability of the tumor mass, direct infiltration of the prostate, uterus, or bladder, distant metastases or an impaired general condition of the patient such as advanced age, advanced tuberculosis, heart disease, etc." Occasionally, cases are considered inoperable at first examination which are later deemed operable after the effects of the irradiation are made manifest; such instances are not common, but they certainly do occur. When palliation only is indicated, the radiologist should make no attempt to cure an advanced rectal cancer with radium or X-rays, or both, because this entails a drastic procedure. In such an instance the patient's tolerance and health should be conserved by a prolongation of the period of irradiation over several weeks, using interrupted and weak treatments repeatedly to secure growth restraint and induce abortive fibrosis in the cancer. When a curative effect is planned, all the radiation treatment should be given within eight or ten days. Liver metastases are treated cautiously with suberythema doses from three directions; they respond fairly well to tissue dosages of 110 per cent of an erythema unit, but the three treatments should not be given within a short period of time.

Before the rectal cancer is irradiated, a colostomy, or the forming of an artificial anus, should be done. The reasons for this are as follows: *(a)* the diseased part should be put at rest; *(b)* the shunting of the fecal current will permit the infection of the ulcerated cancer to be treated; *(c)* it permits exploration of the abdomen and the determination of the extent of the cancer and its regional and visceral metastases, if present; *(d)* at a later date the fibrosis following the radium therapy may partially

occlude the rectal lumen. Some men, such as the French surgeon Proust, of the Hospital Tenôn, will not treat rectal cancer unless the patient consents to a preliminary colostomy. Radiologists must appreciate the necessity of laparotomy, as this affords one of the best avenues for the insertion of radon seeds into the primary tumor as well as into any outlying metastases to lymph nodes. It is fallacious to expect control of the cancer by the energetic irradiation of the primary lesion when the anorectal, retrorectal, and paracolic lymph glands are involved. Sir Charles Gordon-Watson inserts the radium-bearing implants into the rectal cancer by the transperitoneal route at the time of this laparotomy.

Within a few days after the colostomy has been performed, the irrigation of the lower loop is begun, using 5 per cent sodium bicarbonate solution for cleansing purposes. In the absence of feces and with continua irrigation the infection subsides and the tumor seems to become smaller. Two weeks after the colostomy is made, a pelvic cycle of X-irradiation is given, followed almost immediately by interstitial radium therapy. The colostomy opening, or stoma, is pro-

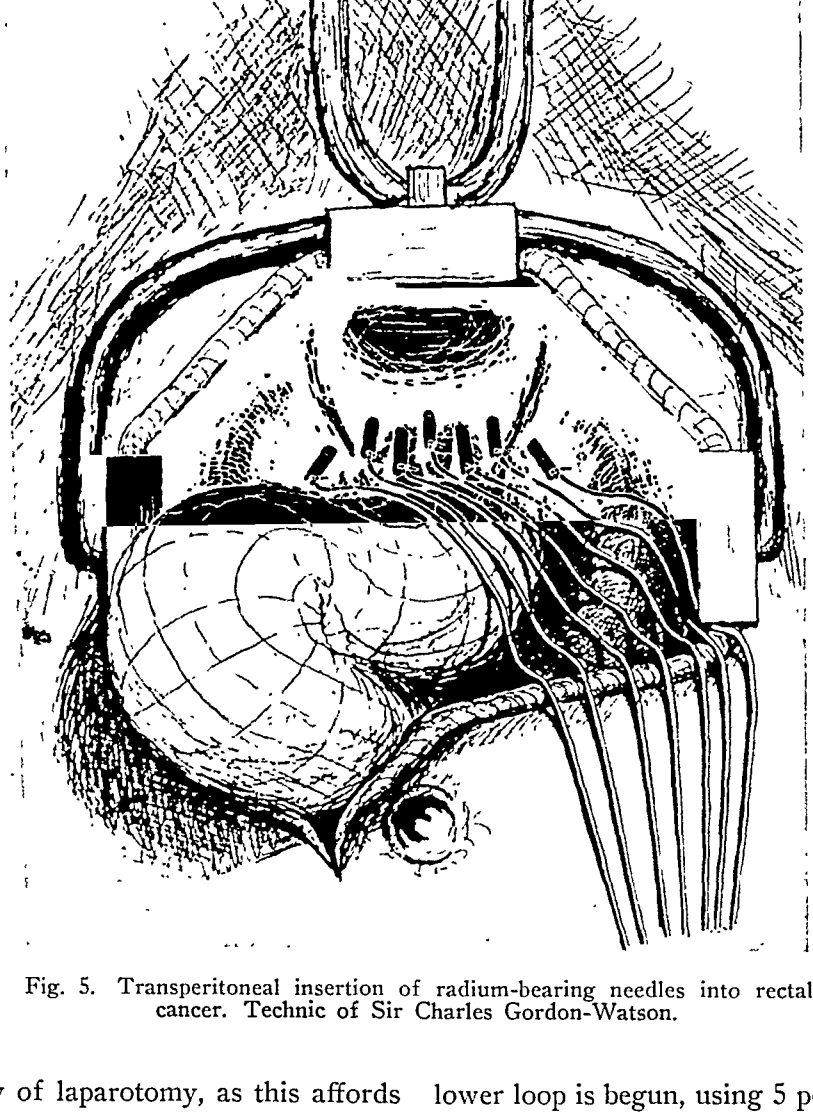


Fig. 5. Transperitoneal insertion of radium-bearing needles into rectal cancer. Technic of Sir Charles Gordon-Watson.

tected by leaded rubber in order to prevent injury by the X-rays to the delicate susceptible mucosa of the colon.

In a pelvic cycle of external irradiation, usually by X-rays, we employ four or five fields; two anterolateral fields and two posterolateral fields, including the sacral area. Care must be taken to prevent overlapping of the skin portals. When the cancer is situated low in the rectum, a perineal portal may be added, in which case only 80 per cent of an erythema dose is given to the area because of the sensitiveness of the vaginal and anal mucosa.

The tolerance of the small and large intestines to X-rays should be considered. Wintz states that the small will tolerate 30 per cent more irradiation than will the large intestine. May gives the following degrees of reaction of the intestines to various tissue doses of radiation: 80 per cent erythema dose may cause a slight erythema of the intestinal mucosa, with an abundant discharge of mucus; 110–120 per cent erythema dose may produce genuine inflammation, with fibrinous exudation and a bloody mucous discharge; 130 per cent erythema dose causes ulceration of the intestinal mucosa. Consequently care must be taken to direct the rays toward the rectal lesion and to secure a homogeneous field of radiation.

External irradiation lessens the hemorrhage from the cancer, diminishes the toxemia from absorption, and later decreases the infection of the rectal cancer. Cancer of the rectum cannot be cured by external irradiation alone. This is because 125 to 140 per cent of an erythema dose, which is delivered to the tumor by a pelvic cycle of X-irradiation, is insufficient to sterilize the most radiosensitive tumor. So-called cures of rectal cancer reported to have been accomplished by external irradiation will be found to be cases which have not been free of disease for five years.

For the employment of local radium therapy, the amount of radium and the filtration necessary depend on the site and size of the tumor and the time of irradiation. Radium applicators for surface application cannot be satisfactorily used in the rectal canal because *(a)* the dose is too superficial; *(b)* the length of time will not permit effective irradiation, and *(c)* there is some danger of the applicator slipping and losing its contact with the cancer. If topical or surface application of radium plaques is to be used as an adjuvant measure in the treatment of flat, ulcerating growths, the patient should be placed in the knee-chest position and the rectum thoroughly packed after the placement of this type of applicator. Then the patient rests in bed quietly without movement during the treatment.

Interstitial irradiation is the really effective method of radium therapy. Metal radon implants of gold and platinum eliminate 97 to 98 per cent of the more destructive energy, so that even slight necrosis does not occur after the implantation of these seeds—success absolutely depends on proper dosage and accurate placement of them. The radium therapist can detect the difference in resistance of cancerous and normal tissue, when the hollow needles are inserted for the deposition of the radon seeds.

After the radon seeds or element needles are inserted in the rectal cancer, the rectum should be packed with rubber tissue to keep the needles well embedded in the growth, to maintain their proper emplacement, to protect the intact mucosa below the growth from the close proximity of the needles or radon seeds, and to allow the free discharge of blood and infected fluids from the surface of the growth.

Frequently we prefer to use radium element needles of 10 milligrams strength and 0.5 millimeter filter. Sometimes ten or fifteen of these needles inserted into the rectal cancer are necessary for effective irradiation; for this purpose we prefer to have the

patient in the lithotomy position under anesthesia. Either sacral or spinal anesthesia is a satisfactory method, or nitrous oxide anesthesia for the short time necessary to introduce the needles or seeds.

All of the rectal cancers are treated from below, but, in addition, certain of them can be treated from above, *e.g.*, cancers at the rectosigmoidal junction are best treated from above and below. An operating cystoscope may be inserted into the colostomy opening from above, and gold or platinum radon seeds introduced into the superior portion of the rectal cancer by special hollow needles; or a small proctoscope or sigmoidoscope may be inserted from above downward and needles with thread attached introduced through the channel.

If the cancer is on the anterior rectal wall of a female patient, the radon seeds or element needles can be inserted into the cancer through the posterior vaginal wall. Excision of the coccyx and exposure of the rectum posteriorly will sometimes afford a better field for the insertion of gold or platinum radon seeds directly into the tumor growth and into the perirectal structures. If element needles are used through the wound, they should not perforate the wall of the rectum nor perforate the cancer if they are inserted into the cancer from the outside. The anus is sewed up previously to prevent contamination. Or the radium element needles may be introduced deeply into the perirectal cellular tissues by puncture of the perineum and anococcygeal raphé with a trocar. This procedure requires rigid asepsis and constant dressing, if it is not to be followed by perirectal suppuration.

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fitted to judge. Without exception, they have indicated to the writer their belief in the efficacy of the new method, and expressed the hope that they will be able to be of greater service to cancer patients than formerly.

It is a good omen to note that all of these men are cautious in their statements. They rightly feel that a great deal of exploitation has already been accorded radium, to the detriment of its scientific status. Therefore it is a pleasure as well as a privilege to state that the most enthusiastic comment elicited from a leader in massive radium therapy is that he believes radium mass in dosage of four grams or more has an action on tumor cells not hitherto achieved, and that he hopes hereafter to obtain better results than ever before. The writer has, for a number of years, been an earnest student of this problem and has felt himself unable to render to the cancer sufferer the full benefit which would have accrued had he been possessed of adequate radium equipment.

It is not intended to convey here the impression that unless one has four or five grams of radium he cannot to an effective degree cope with cancer. Many radiologists with a small amount of fifty or one hundred milligrams can perform excellent work in uterine carcinoma or in suitable local lesions, but such work is strictly limited to private practice and has no bearing on organized community work in dealing with cancer.

No individual physician or group of physicians depending upon their practice for maintenance could set aside funds sufficient to purchase a large working quantity of radium—meaning a minimum quantity of four grams. This amount at the present market price costs $228,000. Placing this in the proper cannon or bomb for service, and adding other necessary equipment, would increase the price to some $300,000. It need hardly be emphasized that such a radium container must be placed in a suitable location surrounded by all necessary protective factors, and, most important of all, in the hands of those only who are qualified by training and experience to use it safely.

Up to a very few years ago, radium clinics were almost unknown. In America there were only two units, and two in Europe. To-day in Europe alone, approximately 35 grams of radium is in use—an amount exceeding the world's entire supply ten years ago.

There are probably in the world to-day not more than fifteen medical centers where radium in sufficient quantity to cope successfully with major cancer work is available. These centers are approximately equally divided between the two hemispheres. In America, 80 per cent of the radium depots are in the extreme eastern part of the country. In Europe, practically all the radium is located in the countries bordering the North Sea.

In view of all the foregoing facts, we are confronted with the problem of providing properly equipped clinics, available to patients of varied financial status; of increasing our supply of radium, and of educating the public—and to a degree the medical profession—as to the specific value of radiation treatment, in addition to the other means at our command.

The first two requirements involve financial difficulties. The help of municipalities or states might be obtained in some cases; in others, private aid would be forthcoming. There are in America not a few wealthy and philanthropic individuals who might be interested in helping such a cause if they were made acquainted with the facts, and it is sincerely to be hoped that a movement to enlist their help will be organized without delay.

The distribution of cancer clinics should follow a well directed, country-wide plan.

It would be poor practice and economy to scatter fractional amounts of radium in small communities, or in several centers in large cities.

Whether such clinics could be placed on a basis which would make them self-supporting, after the primary outlay was secured, can not be predicted with accuracy. Many patients could contribute something to the upkeep, and well-to-do patients might be more liberal. However, the clinical center might even then need to be subsidized to some extent.

With such cancer clinics established, it would not take the public long to realize that here was real help available in certain definite fields. By the same persistent and cooperative methods as were inaugurated by Finsen, of Copenhagen, in the campaign to stamp out lupus, we may hope for parallel results with cancer. In the space of approximately twenty-five years, lupus has become a comparatively rare disease instead of a widely prevalent scourge.

To best achieve the desirable ends under discussion will require painstaking and persistent work—a relentless publicity campaign in which all medical men should unite. The public must be given the facts and continuously urged to come to their doctor at the first unusual symptom. When they learn that cancer is curable in case the primary lesion can be destroyed, their confidence will be gained, and little by little the secondary and tertiary stages of cancer will lessen in frequency.

This may seem a long path and the writer's viewpoint may be criticized, yet he believes that when the whole question of cancer is fairly before us and when all actual facts which have been accumulated are critically analyzed, one will acknowledge that there does not seem a reasonable prospect of finding in the immediate future a specific remedy for this dread disease. We must, therefore, increase to the fullest extent the effectiveness of the means which are at the present moment under our command.

DISCUSSION

Dr. George E. Pfahler (Philadelphia): In the first place, I believe that we should get help in 90 per cent of these cases of carcinoma involving the accessory sinuses, as we see them in Philadelphia, from a study by means of the roentgen rays, instead of 5 per cent. Certainly that is our experience. It may be that Dr. Quick gets these cases in a much earlier stage, and I believe that probably in the earlier stage the X-rays will not be of great help in making a differentiation. One of the chief factors in the diagnosis of carcinoma in any part of the body is invasion, and if, in the study of the accessory sinuses, you can establish invasion, and if you have carcinoma involving, for example, the maxillary sinus, there is apt to be invasion of the surrounding structures, and you will get erosion and decalcification of the neighboring bones; then it is rather definitely localized. That is, it is not a general decalcification affecting all the bones of the face, but, rather, the bones in the region of the tumor area. It can be traced back into the ethmoid cells, and if those cells are destroyed, and particularly if they are destroyed on one side, one recognizes the condition as one of carcinoma. If there is erosion in the floor of the orbit, in the inner wall, or in the superior wall of the orbit, when the ethmoid cells are involved, there is present an indication that one is almost certainly dealing with malignant disease.

I agree with Dr. Quick in that we must judge each particular case by itself and adapt our treatment to the individual case in hand. If the patient needs drainage, drainage must be established; but I also agree with him that we must not operate merely for the sake of taking away part of the tissues. I believe, with him, that a microscopical study and a biopsy should be

made with as little trauma as possible, excepting only instances when that trauma must be done for the sake of establishing drainage or finding means of applying radiation to the disease.

I agree with Dr. Widmann that the method which he has described and which, as he well knows, we have used in our office for about three or four years, is highly effectual. It is based chiefly upon the second principle brought out by Regaud, namely, that the more highly filtered your radium is, the less damage there will be to the normal tissues, and by this high filtration and the prolonged irradiation which is possible as a result, you are also to destroy the carcinoma tissue with little or no damage to the normal tissue. I made a report on this subject before the international conference on cancer in London last Summer, and it was a great satisfaction to me, when I visited the radiological institute—the Radiumhemmet—in Stockholm, and the Radium Institute in Paris, to find that they were using exactly the same method, namely, high filtration, prolonged irradiation, and radium packs wherever there was room or opportunity to apply them. They were thereby getting results with almost no destruction of normal tissues, and that is the principle. Inside the mouth you cannot use radium packs. You must, by means of these lead applicators, as Dr. Widmann has described, apply them in different parts of the mouth. I commonly use 2 mm. of platinum, which is equal to about 4 mm. of lead, but anywhere from 1 to 2 mm. of platinum—1 mm. of platinum in filtration is equal to about 2 mm. of lead. By this high filtration, one gets a tremendous effect on the cancer cells without great damage to the normal tissue cells, and I think that is the great secret of success. I have had the experience in four cases of getting complete disappearance of the cancer after it had invaded the interior of the maxillary bone—clearly demonstrated, so that there could be no question as to the invasion—and get complete recovery, with retention of the bone structure. While I was visiting the Radium Institute in Montreal in October a year ago, Dr. Gendreau showed me two cases, with involvement of the lower jaw bone, in which he had obtained just those results, namely, recovery by the use of this very highly filtered radiation. More and more I am using 2 mm. of copper filtration in connection with high voltage rays. Now perhaps the physicists say there is no difference, and some of the biologists claim there is no difference in the tests they have made, but from a clinical standpoint there is no question about it in my mind—that the high filtration gives different results from those you obtain from the lower filtration. Even in the book translated by Dr. Schmitz, Friedrich's experimental work, you will find it recorded that the biological effect for the same amount of intensity of irradiation is two and a half times as great when you are using pure gamma rays as when you are using any of the various grades of X-rays. This writer found, as probably all of us have found, that in proportion to the intensity delivered to the affected parts, there is practically no difference between no filtration and up to half a millimeter of copper, but I do believe that we have unquestionably better clinical results.

Dr. Soiland has struck the keynote of the whole cancer problem in urging that we educate the public to the importance of early recognition of cancer and the early and complete treatment from the very first sign of it. If we can do that, many of these other problems will disappear.

DR. DOUGLAS QUICK (closing): Just one word about the paranasal sinuses in order that Dr. Pfahler may not misunderstand what I was saying about radiographic diagnosis. I was referring to those cases in which we would have to depend entirely upon films to make a definite diagnosis of

malignant disease. We get a great deal of help, of course, from films in the more advanced cases, where we can clinically determine pretty much the same thing by various direct examinations alone. If we could get more help in the earlier diagnoses of these lesions and the differentiation of them from the inflammatory processes, we would be a good bit ahead. May I add one word to Dr. Widmann's paper, anticipating his closing later?

THE CHAIRMAN: Certainly.

DR. QUICK: I just want to add a word of appreciation of Dr. Widmann's presentation on combining the various qualities of radiation. I believe we sometimes think too much of the quantity of radiation and give too little thought to the quality. While, from the biological standpoint, some of the clinical observations are not entirely supported, I think the more we have clinical observations from different centers and clinics, the more we will be encouraged in believing in them. We have felt that the shorter wave length of heavily filtered radium, in combination with X-radiation, permits considerable clinical advantage over using the radiation of just one type. I was particularly interested in the diagram of irradiation within the mouth, showing the rather uniform distribution in percentage of erythema throughout the tumor-bearing area. I wish Dr. Widmann would tell us, in closing, something of the histology of these metastatic growths in which metastatic cervical nodes regress on gross examination for a temporary period. I ask that for two reasons, the first of which is because of the percentages which he had on that slide, which were around three, four, and five erythemas. There are certain of the embryonal epidermoids, transitional cell types, etc., which three or four erythemas, or occasionally even less than that, will apparently completely clear up. With the adult type, however, it has been our experience that it takes seven to ten erythemas to actually eradicate the disease, and I cannot get that out of mind, when we see what would appear at times to be rather unusual results. Sometimes I wonder if masses that seem to disappear permanently, metastatic from adult types of growth, may not have been put down on the record as metastatic, but are probably in the end inflammatory. I wonder if we sometimes do not misinterpret bone changes about the jaws when they are inflammatory rather than definite extensions into the bone. We have had difficulty aplenty with the secondary invasion of bone in adult types of epidermoid carcinoma, and except where occasionally a large area of bone is completely devitalized by irradiation and later exfoliated, I have not seen definitely proven secondary invasion of bone cleared up by any type of irradiation without sequestral separation.

DR. PFAHLER: Dr. Quick has asked me to make an explanation which I took it for granted was understood. In speaking of these bone carcinomas, we give as high as sixty thousand milligrams of radiation externally, and we give three to four thousand milligram-hours inside the mouth. All of this treatment to affect a carcinoma of the jaw is not given externally, but is given intra-orally, as was indicated in Dr. Widmann's paper, and I took it for granted that that was understood.

DR. HENRY SCHMITZ (Chicago): The papers presented hardly permit of a discussion. They are of so masterly a character and are based on such a vast number of observations that little can be added. The results given correspond to those published in the literature. Dr. Healy stated that priority for the combined X-rays and radium treatment in carcinoma of the cervix should be credited to Dr. Bailey. If Dr. Bailey started the method in 1915, I preceded him at least by one year. I wish to say that we have used the small field method since 1912.

We added radium to the X-ray treatment in the beginning of 1914, and the first report of this work which we had done was made at the meeting of the American Medical Association at San Francisco in 1915.

As far as the histological grouping according to the predominating cell type is concerned, we feel that the cell type alone is not as reliable an index of the degree of histological malignancy as the study of anaplasia, differentiation and undifferentiation, and the behavior of the stroma. I shall consider these factors in a paper to be presented this afternoon.

There is a tendency in the various clinics to increase the radiation doses, especially in the prickle-cell and transitional cell type cancers. This change in treatment may be attributed to the scientific investigations of the radiosensitivity of tumor cells by Ewing. Ewing's work has influenced radiology more than any other factor. It has taught us to corroborate our clinical observations with pathological evidence. Ewing's deductions are so logical and so scientific that it has been impossible to refute them by any means whatsoever.

EDITH H. QUIMBY, M.A. (New York): I should just like to describe briefly the way in which we derived those tissue doses Dr. Healy presented. The method of determining tissue doses due to X-rays is well known and need not be discussed: the dose close to a small source of radon actually placed within the tissues is quite another matter. For the bomb and the tube we have used the method of submerging both the radiating source and the measuring ionization chamber in the water phantom, and determining the relative intensity of radiation at different distances from the source. For positions close to the source, the possible error is rather large, due to the size of the ionization chamber relative to the distance considered. For larger distances this factor is less important. These measurements gave only relative intensities. For the actual erythema dose, that is, the amount of radiation from a tube necessary to produce a threshold erythema, a different type of experiment was necessary. The tube was embedded to a known depth in beeswax and strapped to the skin of patients for varying lengths of time until the dose was found which produced a faint erythema in 80 per cent of all cases and no visible effect in the other 20 per cent. This is 150 mc.-hr. through a centimeter of wax, or tissue. Then a treatment of 1,000 mc.-hr. with a single tube would deliver 6⅔ erythema doses at a distance of 1 centimeter. The data obtained with the water phantom permit the calculation of the erythema dose for other distances. The erythema dose for the bomb has been determined in a similar but somewhat more complicated manner. On Dr. Healy's figure, the doses indicated for the points very close to the tandem are very great. They are subject to a large error, as I have stated. For these points this is unimportant. We know that they get very much more radiation than they need, but they must, if more distant points are to be adequately irradiated. The doses indicated for points at greater distances represent quite well the amount of radiation actually delivered there. What we hope to do after study of a large number of cases, is to find the amount of radiation which we may expect to produce satisfactory regression, and then to try so to plan our treatments that every part of the lesion shall receive at least this dose.

DR. FRANCIS CARTER WOOD (New York): What impresses me as the most interesting part of the presentation is the convergence of opinion which is so evident—the codification, so to speak, of various technics —the appreciation of the value of histological studies of the tissues, not only of the epi-

thelial cells but of the connective tissues also, and the accurate measurements of dosage, combined with an approach to a standard method of treatment. It is interesting to note also that the early experiments which were done in the laboratory on animal tumors are now being confirmed by the studies on human tumors. In the early publications it was stated that four to six erythemas were necessary to kill all the cells of an animal tumor. We are now appreciating that this amount or even more must be given to obtain cures in human carcinoma. I feel that those who have the large choice of material at their disposal owe to the rest of us who perhaps have not so much, the publication of monographs not only including the clinical history of the case with the results of physical examination, but also photomicrographs of all tumors and vastly more detail as to treatment than we can get from papers of the type read here. The Mayo Clinic, and the Memorial Hospital, of New York, I think, might well issue a complete and detailed atlas of the type of tumors which they treat, together with the results, in order that pathologists throughout the country may learn of the detail of the tumor groupings and the clinical results which have been obtained. There is a good deal of divergence of opinion still as to the grouping types and some criticism of the value, which I think is quite unwarranted. No one thinks that by examining a bit of a scraping from a cervix that a prognosis as to the ultimate cure can be given, because that is only one portion of the condition. After all, the smallest cervical tumor, which any one would think was curable with perfect ease by radiation or by surgery, may already have metastasized to the pelvic nodes, something which can never be determined and the reason, I think, why we still do not get 75 or 100 per cent of cures even in favorable cases. But just such mass material as these large clinics have in their records is invaluable, if it can be given in great detail. There are monographs published on vastly less important matters than these.

It is interesting to hear Dr. Healy say that they treat certain advanced cases with X-ray first. That, as you know, is Regaud's practice. I have seen a patient who could not come into the hospital for a couple of weeks for personal reasons, whom we treated with X-ray. When the time came for the insertion of radium, the tumor had entirely disappeared. The radium was inserted, however, since which time—a year and a half—the patient has been without the slightest symptoms. This shows what can be done by radiation externally as a preliminary cleanup preparatory to the insertion of the radium, which is, however, also necessary, in my opinion, to get the high local dosage required to destroy the tumor cells. After all, we must realize that no matter how carefully we group or how thoroughly we study these tumors morphologically, only an approximate idea is obtained of their biological peculiarities. An experiment which was done in my laboratory by Dr. Woglom and has long since been forgotten illustrates this point. Three breast tumors occurring in the same mouse were transplanted into a large series of animals. These breast tumors are indistinguishable in their morphology, but one tumor took in about 80 per cent of the first inoculations, showing it to be of very high malignancy; another tumor took in about 50 per cent, showing moderate malignancy, and a third tumor took in 8 per cent, which is about the malignancy of a basal-cell tumor of the human skin. These fluctuations can be eliminated only by mass statistics, and a combined study of three or four thousand cervical tumors, with suitable pictures of selected fields, would be an invaluable contribution to cancer. This can be done by two or three large institutions in this country.

It is perfectly evident that the time has passed for surgery of carcinoma of the cervix. It is also perfectly evident that the

general surgeon or the general radiologist is not in a position to treat these patients as effectively as they can be treated in large institutions. The inevitable result must be the concentration in institutions of large amounts of radium, which the ordinary hospital cannot afford to purchase, and the concentration also of patients in special institutions where such treatments can be carried out according to standard methods. I do not agree with many that the treatment of carcinoma of the cervix with radium intelligently and properly is a very easy matter. It requires experience; it requires ample equipment and careful measurements. How many hospitals have a physics department that can carry out the measurements which have been discussed here to-day? How many have a gram or two of radium available for the few cancer patients they will admit? It means, I believe, that ultimately there will be throughout the country special cancer institutes in which the patient suitable for radiation therapy can be treated in the best possible way.

DR. HAROLD SWANBERG (Quincy, Ill.): There were several points concerning Dr. Healy's paper which I should like to emphasize. The first is in regard to the cervical infection that invariably accompanies cervical carcinoma. I think most radiologists have not appreciated the importance of controlling this condition before proceeding with the radium treatment. There is a tendency among a good many radiologists, as soon as they have diagnosed a carcinoma of the cervix, to immediately apply radium. This, to my notion, is somewhat of a mistake.

We may secure an undue temperature reaction and a severe complication if we apply radium before the patient has had an opportunity to partially recover from the infection that invariably accompanies these cases. Our method of procedure is the same as Dr. Healy is doing, that is, copious, warm, vaginal douches two or three times a day, administered for a week preceding the insertion of the radium. During this same interval, we institute our X-ray treatment. If I understood Dr. Healy correctly, I believe he said that in the majority of his cases he used the X-ray following the radium treatment. Dr. Wood, I believe, interpreted this point differently. We are giving a more intensive, or I might say a more saturated, method of treatment than Dr. Healy is giving. Instead of giving five exposures, our treatment lasts over two or three weeks, keeping the X-ray dose at the so-called saturation point.

If we are going to really accomplish a great deal in the treatment of carcinoma of the cervix, we must adopt a method of treatment that can be generally carried out, because it is impossible to get all of our patients to the few cancer clinics that have a comparatively large amount of radium available. I think the average radiologist should not be discouraged because he does not possess a gram of radium, and that a great deal can be done for these patients with smaller amounts, in the same manner that Regaud is applying it at the Radium Institute of the University of Paris. You will recall that he is using between sixty and seventy milligrams of radium to treat his cervical cancer patients, and I think his results compare very favorably with some of the best work done in this country. Dr. Healy evidently does not think well of long continued radiation as compared to radiation administered in comparatively short periods of time, but, on the other hand, the results he is able to attain are not a great deal superior to those Regaud has secured with the "small amount, long duration" technic.

DR. GEORGE E. PFAHLER (Philadelphia): Any report that Dr. Schmitz makes is bound to be instructive, because he goes into the conditions so thoroughly. He has made a real contribution to radiology in his group-

ings, particularly of carcinomas of the cervix. He first gave this grouping at the New Orleans meeting of the American Radium Society, and I am sure that this has helped, to a great extent, to clarify the classification of cases and to help us to determine about what our results should be and what the line of treatment should be. He has carried this on to the study of breast cases, and there can be no question as to the value of this grouping. I agree thoroughly with him that we should eliminate the words "operable" and "inoperable," because the question of operability is influenced by too many factors which vary with the individual operator. In some instances the surgeon is influenced by his interest in the patient, sometimes by his interest in his statistics, and in others merely by sentimental interest; but grouping these cases pathologically or by the extent of the disease will help us in the future to learn what should be done in any particular group under consideration. Now I personally am more impressed by the clinical grouping than I am by the histological grouping, because the important thing, when a patient comes before you, is to know what shall be done with this patient. If you operate in order to get the specimen under the microscope, you have already decided what you are going to do, and while it is of scientific interest to work out these problems and determine how nearly they fit in with the clinical problems, the clinical grouping is certainly of the greatest practical importance. Dr. Schmitz' classifications, both the clinical and the histological, have apparently fitted in very well. I would like to hear, however, in his closing remarks, as to whether the clinical group which he marks "Group 4" corresponds to the histological grouping 4, or whether some of the clinical groups in which the disease was strictly localized also belong to Group 4 of the histological grouping. That, of course, would then necessitate a separate grouping as to the end-results. Dr. Stanley P. Reimann and Dr. Eugene Case, during the past year, have taken a group of breast cases in which the end-result was known, submitted the microscopical specimens to several pathologists, allowing them to classify these cases according to the microscopical findings in these slides. When these end-results were compared with the end-results obtained clinically, unfortunately they did not correspond in any sense. Now, in making a specimen for microscopic study, we must bear in mind that a great deal depends upon the judgment of the pathologist in picking out the particular specimen he puts under the microscope, for it is utterly impossible for the pathologist to examine all of the tissues, and this fact must influence the final grouping. Dr. Schmitz has brought out another very interesting clinical fact, namely, that his figures are 17.5 per cent of cures—five-year cures—counting all of the cases, or, in other words, the absolute cures. These correspond pretty generally with the results that are being obtained throughout the world, and they are very similar to the results obtained whether the patient is operated upon or treated by irradiation. Likewise, the results obtained in the localized and borderline groups, Class 1 and Class 2, according to Dr. Schmitz' grouping, run somewhere between 40 and 45 per cent very generally throughout the world. There, again, the end-results are very similar, no matter whether the cases are operated on or treated by irradiation. We have, however, favored irradiation as the best treatment, eliminating about 17 per cent mortality from the Wertheim operation in carcinoma of the cervix. It would seem that if we can educate the public and the men in general practice to pay attention to the earliest signs of malignant disease and have the cases treated either by radiation or operation, we would get results up in the region of 60 or 70 per cent. I believe if we can spread the information that there is hope of successful treatment of the primary lesion in the early stage

by irradiation, the public—the women who have these carcinomas of the cervix or breast—will be more willing to come for treatment in the early stages.

DR. W. H. MCGUFFIN (Calgary, Alberta): Dr. Soiland has made three statements to which we should give some thought.

(1) "Approximately 70 per cent of our cancer cases are incurable," therefore, from the economic viewpoint we should do all possible to prevent this disease, particularly through the aid of periodic health examinations and public education.

(2) That "80 per cent of the cancer patients are financially unable to compensate the medical practitioner for the necessary treatments." This would seem to justify the Doctor's contention that state assistance is, in part, a solution of the problem.

(3) "The advisability of centrally located cancer clinics for the diagnosis and treatment." Truly we are in accord with this point. It is only necessary to study the splendid accomplishments of such clinics in order to make us realize that this constitutes the ideal method of handling our cancer cases.

DR. FRANCIS CARTER WOOD (New York): As I said this morning, the interesting part of all this work is that we are coming to standard methods of radiation. No one has had more influence on our work than Regaud, and the reason why Regaud's work is so good is that he has based it entirely upon biological investigations in which he could observe accurately the changes which took place, with accurate measurements of the quantity of radiation applied. As I remember it, Kroenig and Gauss were the first to call attention to the fact that when equal doses were administered, the effects were equal. These were, however, doses administered at a fairly rapid rate, and Regaud's great contribution to our subject lies in slowing down the rate. If, for instance, you give a sufficient dose to cure a mouse tumor in the animal, you will get a severe radiation burn; if you split that dose into two or three, you can cure the tumor without damage to the skin. The reparative processes of the normal tissues, of course, are greater than those of the pathological in many instances—not always. The cases in which it is no greater are those which escape any benefit from radiation. In those in which there is a differential, there is an advantage in greatly prolonging the time, if possible, and that touches very closely Dr. Soiland's point of the institutional treatment of cancer. If we are going to treat patients with prolonged doses of radium, they must be kept under observation in hospital wards for periods of from two to three weeks, during which time the treatment is going on. It is Professor Regaud's chief complaint that he has no beds under his direct control and that he has to go to distant hospitals to follow his patients, where he can have no satisfactory supervision over them. If we are going to radiate patients with a filter of two millimeters of copper and gain the benefit of prolonged radiation, they must be hospitalized. Very few patients will stand the dosage given by Dr. Coutard and his assistants—five hours for ten consecutive days; that is beyond the endurance of most human beings. The principle is to catch the cells when they divide and to prolong the time sufficiently to get all these cells and at the same time spare the normal tissues which can regenerate more rapidly than the abnormal, owing to their greater vascularity and other qualities which we do not fully understand. Whether we will ever achieve 100 per cent with all these methods, is, of course, extremely doubtful, but every year shows a distinct gain over the previous one. However, it must always be remembered that every time a meeting of this Society has been held, someone has hoped

that some particular technic of his was better than anyone's else, and we know that these ideas and impressions are not always the best guide. The only way to advance steadily is to combine all the information we have, to compare notes as much as possible, to visit one another's laboratories and institutions, and not to remain too isolated. There are important facts to be learned in Stockholm, in London, and in Paris, and it is to be hoped that the information which is available in published records will be carried throughout the United States. I hope this may be accomplished by the new extension of the Journal of the Radiological Society which promises so much. I would like to see that Journal contain translations of the more important contributions of the French and German radiologists, which hitherto have evidently escaped the eye of many of our colleagues.

DR. B. P. WIDMANN (closing): If we are to depend upon the caustic action of radiation in the treatment of deep-seated malignant disease, then obviously radiation therapy can never be considered as an ideal procedure, because adequate intensities in the deeper-seated structures cannot be attained without danger of damaging the integrity of the normal tissues. Every effort during the past year and a half has been spent in building up doses that will permit the delivery of two to three times the usual amount of treatment, and this could be done only by using extremely short wave length radiations. The principles expounded by Regaud, of the Curie Institute in Paris, are being adhered to insofar as continuing radiation over a long period of time (a total of from 8 to 10 days). We have not had an opportunity to have histological studies of enlarged lymph nodes made. We hope to be able to present some study of the tissue changes following extremely short wave length radiations in the near future. In two recent autopsies on patients with advanced pelvic cancers, Grade 4 involvements, all evidence of disease in the pelvic region had disappeared; in one case metastasis to the liver was found and in the second case no evidence of disease could be determined anywhere. In another instance a patient is still living and symptom-free following treatment for an extensive pelvic cancer causing a rectovaginal fistula. There is no proof that the better biological effects will be obtained by short wave length radiations. There is evidence to support both types of radiation, but if further progress in the treatment of advanced cancer is to depend upon the principles of radiation, then it is reasonable to assume that some means of delivering still greater quantities of radiation to the tissues must be devised. This development must naturally be along lines of using qualities of radiations that will preserve normal structures and still be elective for cancer cells.

DR. G. E. BINKLEY (closing): I cannot agree with a previous speaker, because the amount of radium at our disposal is limited. Under these circumstances, radium should be used at the portals of entry which allow the greatest dosage at the site of the tumor, and high voltage roentgen rays, which are available in unlimited amounts at a very low cost, at the portals where a smaller fraction of the skin dosage reaches the tumor mass.

DR. ROBERT E. FRICKE (closing): I agree with Dr. Healy regarding the management of the cases in which there are foul and sloughing growths. It is usually more expedient to clean up the necrotic field and apply vaginal packages of radium before the intracervical or interstitial applications are started. We usually divide treatments, using the universal 50 milligram applicator or an equivalent radon tube, and a complete treatment may consist of six to eight portals over a period of two to three weeks. Between treatments, patients are permitted to

be up and about, so as to maintain or conserve their general health and strength. The best results are obtained by intensive treatment, to suit the individual needs of the patient. In the inoperable group, with health undermined, only limited treatment should be attempted; however, in a few of these cases complete treatment will be well tolerated.

Dr. William P. Healy (closing): Dr. Swanberg and Dr. Wood are both correct in their conclusion from my paper. We formerly treated all our cases with radium as the first application, radium *per vaginam* and the bomb, or some application against the surface, and then the radium capsules within the cervical and the uterine canal, and by burying gold filtered seeds in the outer borders of the cervical lesion. Then, ten days to three or four weeks later, depending on the amount of the constitutional and local reaction to the application of the radium, we followed that series of treatments with the X-ray cycle. However, as I stated in the latter part of my paper, we are now doing a different procedure, particularly in the 60-odd per cent of advanced cases. In those, we endeavor to precede any radium application by the high voltage X-ray cycle and the use of copious antiseptic vaginal douches. We believe it is a better procedure for that group of cases, and I am not so sure but that I shall also, in time, treat even the early or favorable cases in the same way, by giving them the X-ray cycle first.

I feel that there is room for small groups of men here and there about the country, with small amounts of radium in their possession, who are interested in the cancer problem. I feel that there is not only room, but a great necessity for such groups, and that they can treat cancer to advantage. I feel that large institutions have a wide field because of the great number of cases treated by them. They represent centers of education and instruction, because of their large endowments and their laboratory facilities for research. They are very necessary, but I feel that the treatment of cancer cases throughout the country can never be properly carried on unless individuals here and there who are interested in the subject can continue to do their work.

Dr. Henry Schmitz (closing): I wish to thank Dr. Pfahler for his very kind discussion. His expression of appreciation of the work presented here to-day means more to me than one may realize.

The Clinical Group 4 carcinomata differ from the Histological Group 4 carcinomata. The Clinical Group 4 carcinomata are determined by the extent of the growth; chiefly whether it has caused metastases or whether it is fixed. The Histological Group 4 carcinomata are determined by the microscope and are characterized by a high degree of anaplasia and undifferentiation. One may find a Histological Group 4 carcinoma in a Clinical Group 1.

Broders, Greenough and others influenced us to apply their findings to our cancers. The only difference is that Hueper has attempted to name the various factors which constitute the malignogram and to give a method of numerical evaluation for each one of these factors. Thus the work may be duplicated by any one familiar with pathology. The clinical grouping, also, has advantages. It gives definite indications for the method of treatment which will prove adequate; it aids in the prognosis, as one may determine the relative chance of result of treatment. Finally, it gives a definite explanation of a clearly localized, a doubtfully localized, and an advanced and terminal stage of cancer.

Dr. Albert Soiland (closing): I am sure you all agree that the value of these cancer symposia can hardly be overestimated.

If we come together year by year in this manner, we will certainly acquire more knowledge, learn what the other man or institution is doing, and this type of information in a subject as difficult to understand as cancer, is invaluable. Such a symposium as this contains practically all the present-day knowledge on cancer, and will prove of inestimable value to every institution of learning.

RADIOSENSITIVE TUMORS AND TUMORS THAT FIRST SHOULD BE SUBJECTED TO OPERATION[1]

By JOSEPH COLT BLOODGOOD, M.D., BALTIMORE, MARYLAND

WE are learning that it is impossible to tell, in the early stage of all tumors and local lesions, the exact diagnosis clinically, or to determine, even when a biopsy is done, whether a palpable mass or a bone lesion seen in the X-ray is radiosensitive or not. As our experience becomes larger, we are discovering that many lesions are radiosensitive. Both theoretically and practically, whether there is to be an operation or not, it is wiser to try radiation first (with certain exceptions, to be discussed), either with X-rays or with radium. I have no evidence that this initial radiation is ever harmful. More recent experience indicates that any operation which incompletely removes the tumor locally, produces conditions that make secondary radiation less valuable.

It seems possible to classify local lesions, whether clinically malignant or not, into two groups: The first, those upon which radiation should be tried first; second, those upon which complete excision, with or without biopsy, should be the operation of choice. I will discuss the first group, because there are a number of new features which, so far as I know, have not been dwelt upon by cancer students in their publications.

Palpable Lumps beneath the Skin and in the Soft Parts.—We have classed these in the laboratory under two large headings: benign connective tissue tumors and sarcoma of the soft parts. There are a few subcutaneous tumors of epithelial origin, for example, the dermoid, that occur in the same localities as the benign and malignant connective tissue tumors. However, when the lump is felt in the breast, or distinctly in the thyroid gland, it is my experience that operation, except when the tumor is distinctly clinically malignant, should be the first choice. The reasons for this will be given later.

The benign connective tissue tumors that may occur in the tissues between the skin and the bone, are different types of hemangioma and lymphangioma, of which the former is the more common, and the xanthoma the most difficult to diagnose at biopsy. Then comes the large group of fibromas, so common on the tendon sheaths, and these are often xanthomas. When situated in the abdominal wall they are called *desmoids*. As a matter of fact most of these desmoids of the abdominal wall represent different stages of myositis of the rectus muscle. The benign connective tissue cysts are simply rare types of angioma, or of traumatic origin. There is no necessity here to go further into the various types of sarcoma. The most striking feature, in our studies of some five hundred cases of sarcoma of the soft parts in the past forty years, is that recurrence followed in about one-third of the cases, and as a rule in the cases that recurred the original tumor had been small, easily accessible, and had been removed by enucleation, or shelling out, either because the operator was ignorant of the danger of doing this, or because of the fact that the tumor was near an important nerve or blood vessel. This is especially true when the mass is in or near the parotid or the facial nerve.

I have found that nerve sheath tumors, whether benign or malignant, are often radiosensitive, especially in the early stage. I feel confident that if these five hundred patients whose cases have been studied in the laboratory, had come under observation early and had received X-ray or radium radiation first, there would have been no recurrences locally perhaps, although many of

[1] Written for the Special Cancer Number of RADIOLOGY, March, 1930

them would probably have had to be properly operated on later.

Let us briefly repeat here again the dogmatic statement which, I think, is based on sufficient evidence to justify it, that no harm is done by subjecting a subcutaneous nodule to radiation first, except when it is situated in certain localities, as in the breast and thyroid gland, where experience favors operation first. Radiosensitive tumors—with certain exceptions, one of which is the giant-cell tumor of bone—show, after a few treatments, the same immediate effect as the gumma does after intravenous therapy. It may be helpful to the reader if we here note observations already recorded on this type of tumors in all localities, with some suggestions as to a better method—as least to be tried. This means that we must mix the two groups—those which should have radiation first and those which should not.

Bone Tumors.—I have selected this group first, because the X-ray pictures the actual presence or absence and degree of bone formation and bone destruction, with and without fracture, expansion of the bone shell, etc.

I have observed radiation in every type of bone disease or bone tumor, benign and malignant. The dangers have been those common to radiation by inexperienced individuals—a superficial or deep burn. There is no necessity for this to-day. Take, for example, a bone cyst in the shaft of the humerus in a girl aged twelve. It was observed by experienced surgeons, pathologists, and roentgenologists about five years ago. It was diagnosed malignant and given intensive X-ray treatment. There followed a dermatitis and cellulitis of the skin and soft parts, with destruction of tissue and an osteomyelitis, with the formation of a sequestrum. The girl's arm to-day is almost useless.

The moment one looks at the X-ray film of a bone lesion and then completes the study of the case, one should be able to divide the diseases and tumors into three groups—distinctly malignant, borderline, and benign. If the lesion is distinctly malignant, there is the choice between immediate operation (resection or amputation), or trial of radiation first. My figures show that amputation and resection have accomplished permanent cures—in 1921, 4 per cent, in 1929, 35 per cent. Among these five-year cures by amputation there are none of the upper extremity or scapula, and of the lower extremity only up to the middle third of the femur. But in the past ten years, we have observed sarcoma in the bones of the upper extremity in which the lesion was removable by excision. Two of these cases have reached the five-year period and are well. There are no cures of sarcoma of the upper third of the femur by either amputation or radiation. I have observed one permanent cure[2] of an apparent sarcoma of the upper end of the humerus, now seven years since radiation. This was a typical example of a radiosensitive tumor, the tumor so large and so extensive that it would have had to be removed by an amputation through the shoulder joint, with a piece of clavicle, acromion, and glenoid cavity. There was a palpable soft-part tumor with little or no bone formation in it, and the shaft of the humerus showed bone destruction. It was my opinion that we could exclude any benign condition of bone. Dr. Miles A. Watkins, of Birmingham, Alabama, curetted a lesion of the middle third of the tibia and then gave radium treatment. This patient[3] has now been well for five years. In the laboratory the sections showed a round-cell sarcoma of the Ewing type.

There is recorded in my laboratory a case seen with Dr. Willis C. Campbell, of Memphis, Tennessee, in which the patient has been reported as well within the past few

[2]This case has been reported in RADIOLOGY ("What Every Radiologist should Know about Bone Tumors"), March, 1927, VIII, 195.

[3]This case has also been reported by Geschickter and Copeland in their article on the Ewing Tumor in *Archives of Surgery*, April, 1928, XVI, 807.

months. The X-ray showed a lesion of the lower end of the fibula. The section made at biopsy showed a Ewing sarcoma. There followed treatment with radium. The X-ray examination after the operation showed a complete healing of the bone lesion. There is an increasing percentage of permanent cures in sarcoma of bone, both after amputation and after radiation. No harm, therefore, occurs from trying radiation first in this group which is shown by the X-ray to be distinctly malignant. If the lesion is of the upper extremity and can not be completely removed by resection, continue radiation. If the lesion is above the middle third of the femur, continue radiation. If the lesion is resectable, in the upper extremity or scapula, or can be completely removed by amputation or resection in the lower extremity below the upper third of the femur, operation is indicated, unless there is a rapid disappearance of the palpable swelling and definite changes shown by X-ray examination.

When the diagnosis is doubtful, the part or patient should be put at rest, the involved area should be radiated, and the X-ray films should be submitted to more experienced diagnosticians. *It is safer for the patient to do this than to have a biopsy made and submit sections to a pathologist for diagnosis.* This doubtful group is on the increase. The majority of them proves to be benign. When the X-ray and other diagnostic studies allow the conclusion of a benign tumor, it is a waste of time and money to use radiation, except in the giant-cell group. I have had such success with curetting when the bone shell of the giant-cell tumor was intact that it is still my rule to operate first. When the bone shell is partially or completely destroyed, I am now trying radiation first. This tumor at first reacts in an entirely different way from a radiosensitive malignant tumor of bone. At first there is further swelling and discomfort, later the discomfort disappears and the swelling recedes. So far my observations in three cases have been unfortunate. Two examples of giant-cell tumor of the lower end of the radius subjected to thorough preoperative radiation recurred after curetting and have remained well since resection. A third one, under observation now, of a giant-cell tumor of the os calcis, has shown almost complete destruction of the already partially destroyed bone shell since its first thorough course of radiation. In the Memorial Hospital, in New York, they have had the largest number of cases and the most satisfactory results. But, if radiation is employed in the giant-cell tumor, the treatment must be carried on for one or two years. I am still rather inclined to the opinion that in cases not suitable for immediate curetting, and in all other cases in which there is not a rapid reaction to radiation, if the lesion can be removed by resection and bone transplantation, the latter should be the treatment of choice. Geschickter and Copeland reported in *Archives of Surgery*[4] that no recurrences after resection of giant-cell tumor have been observed. However, if the giant-cell tumor is in the lower end of the femur or upper end of the tibia, and too extensive for resection, radiation should be given its trial to the limit.

To repeat, more bone lesions should first be subjected to radiation. Biopsy should be reserved for the last resort and, if possible, should be followed immediately by amputation or resection. A bone tumor is a lesion which roentgenologists, pathologists, and surgeons should study together before any radical operation is done, and all three should try to keep themselves informed from our rapidly growing experience.

Nerve Sheath Tumors.—There is no positive diagnostic sign that a soft-part tumor is a nerve sheath tumor, except its location near a large nerve, especially if it is situated in the popliteal space, or is associated with

[4]August, 1929, XIX, 169.

definite pain or some sensory nerve disturbance. There are three definite reasons why nerve sheath tumors should be subjected to radiation before operation. First, experience teaches us that they may be radiosensitive. Second, they are often multiple, and when the larger growth is removed, one may fail to see and remove the smaller growths in the neighborhood. In the third place, if the tumor has been given radiation and has not reacted, one is justified, at the operation, in removing the nerve if this is essential to the complete removal of the tumor. The proof of this is shown in a number of observations recorded in my laboratory. For example, a tumor in the right groin; removal by enucleation, in order to save the anterior crural nerve. There was very rapid recurrence. The patient was given the trial of radiation before an operative attempt in which there would have been danger of injury not only to the nerve, but to the artery and vein. The tumor disappeared; there has been no recurrence after five years.

There is a fourth reason for radiation first, as demonstrated by a case recently observed. The tumor, about the size of the end of an adult thumb, could be felt high in the axilla. When touched, there was sensory disturbance in the region of the ulnar nerve down into the little finger. Clinically, it was a nerve sheath tumor. Rather than operate at once and be forced to decide as to resection of the involved nerve in the brachial plexus, for three years this patient was treated at intervals of from three to six months by deep X-rays. The sensory disturbances remained unchanged; the size of the tumor was first slightly reduced, then quiescent, and then began to enlarge. The interesting finding at operation was this: This tumor had such a thickened capsule that we could remove it completely without injury to the surrounding nerves of the brachial plexus and vessels, and it was only necessary to resect the nerve actually involved. As we have had a very large experience in the study of the fresh gross appearance of these nerve sheath tumors, I feel confident that the thickened capsule was the result of radiation. A benign or malignant nerve sheath tumor may have such a definitely thin capsule that shelling out or enucleation will leave particles of the tumor behind—in such a case there is usually, if not always, a recurrence.

In following this rule of radiation in certain subcutaneous tumors on the supposition that they are of the nerve sheath, undoubtedly other types of benign and malignant connective tissue tumors will be radiated. No harm will be done. We have instructed the public—we shall be called upon to palpate a very large number of subcutaneous tumors in the soft parts. In many we can tell the patient that operation or treatment is not indicated until enlargement is observed. Rapid growth in such a tumor, whether of recent or old origin, is an indication for immediate radiation, and if there is not corresponding and immediate checking of the growth, or its disappearance, operation is indicated.

Angiomatous Tumors.—These are more common than nerve sheath tumors. Those in, or just beneath, the skin or mucous membrane can be diagnosed by their color. The deeper ones may give distinct compressibility on palpation. Any angioma small enough to be completely excised can receive this treatment at once if complete excision is not mutilating. All other angiomas should be given the benefit of as long a course as possible of radiation. If this fails, operate. Microscopic studies of angiomas excised after radiation demonstrate that this treatment increases the connective tissue between the blood vessels, whether capillary or not, and usually destroys the capillaries. The failure of radiation is largely due to th presence, in smaller or larger degre cavernous angioma. These blc spaces are too large to be influen

there is a recurrence after the excision of an angioma, whether it had been previously radiated or not, radiation should be given another trial.

Tumors in the Axilla, Neck, and Groin.—These tumors, like tumors of bone, nerve sheaths, and the angiomatous tumors, are frequently radiosensitive. With few exceptions, nothing is lost by trying radiation first when there are single or multiple enlargements of the glands in these three areas. This is due to the fact that the three types of disease of the lymph glands which are malignant, are, for practical purposes, inoperable, or rather, not curable by operation. In lymphosarcoma and Hodgkin's disease, so far as we know, the nests of malignant cells begin in all the areas of lymphoid tissue throughout the body, or ultimately affect them. Lymphosarcoma is much more radiosensitive than Hodgkin's. Many cases are held five years or more. In metastatic tumors of the lymph glands from primary malignancy in an inaccessible place we cannot expect cure from resection. In cancer of the breast it is the rule to remove the lymphatic glands at the primary operation. If the glands are involved, the percentage of cures drops from 70 to 25 or less. I have no evidence that pre- or post-operative radiation improves the number of five-year cures, or protects the individual in any way. This is theoretically incorrect. However, experience of more than seven years with pre- and post-operative radiation has demonstrated that the greatest comfort is obtained by waiting for pain or definite signs of recurrence before instituting radiation. When, in cancer of the lip, the glands were involved and have been completely removed, the five-year cures fall from 100 to 50 per cent. In cancer of the tongue, with involved glands of the neck, the five-year cures fall to 10 per cent. Pre- and post-operative radiation of the neck, when there is a known cancer of the lip, tongue, or any part of the oral cavity or nasopharynx, has been disappointing. There are a few observations in which the patients have lived long enough in comfort to conclude that radiation has been distinctly valuable. It is better to depend upon the education of the people and induce more and more individuals to seek treatment before the glands are involved.

In tuberculous and non-tuberculous inflammations of the lymph glands, which are often very difficult to distinguish from leukemia, Hodgkin's disease, or metastasis, radiation does no harm, and sometimes seems beneficial. The question to settle first when a case presents itself with multiple involved glands in axilla, neck, or groin, with the involvement of one, two, or all regions, is whether a gland should be removed for diagnosis. I would advise the following procedure first: Look at the tonsils. If there is unilateral hypertrophy of one tonsil, give radiation first to the tonsil. The disappearance of this enlarged tonsil almost makes a positive diagnosis of lymphosarcoma. Now go ahead and treat all the lymphatic regions of the body. If the X-ray shows a mediastinal tumor, the diagnosis is almost certainly Hodgkin's or lymphosarcoma, and radiation is indicated at once. If there is a large mass of glands in axilla or neck, there is no objection to their complete removal—it can be performed under novocain or rectal anesthesia, and the operation is neither dangerous nor mutilating.

The same is not true of the glands in the groin. The complete excision of these glands will not cure lymphosarcoma or Hodgkin's disease: it may be justified in cancer of the penis, scrotum, or vulva. It rarely cures. This complete operation leaves a wound that never heals *per primam* —always by granulation, and it is often followed by lymphedema. Many patients are made uncomfortable. So, when the lesion is in the groin, remove one gland only. If there are glands in the groin, axilla, and neck, and a gland is removed from any of

these regions, and found to be microscopically negative for malignant disease, remove glands from the other two regions before concluding that the disease is not malignant. It is my opinion that unless the section of the gland shows definite tubercles of tuberculosis, or many and definite germinal centers without any foreign cells, it is wiser to give it the benefit of radiation, even if the section shows no positive evidence of lymphosarcoma, Hodgkin's, or metastasis.

The mistake we make in radiation for lymphosarcoma and Hodgkin's is that we limit it to the area involved. Should the lymphosarcoma be associated with leukemia, radiate all the skeleton and observe the effect on the leukocytes.

Male Breast.—One evening, a first-year medical student, aged twenty-two, asked me to palpate a small enlargement of the left breast which annoyed him, both from the pressure of his clothing and because his companions joked him about it in the shower-room. It had been present for three years. There were no signs of malignancy. The left breast was simply larger than the right. It had all the appearance of the so-called diffuse hypertrophy of the male breast, which as a rule becomes bilateral within six months to a year. But when males consult physicians for an enlargement of one breast during the cancer age, it is dangerous to wait for the positive signs of benignancy—bilateral enlargement. So far as I know, these breasts have not been tested as to their radiosensitivity. It is the first opportunity I have had in three years to see such a case. I may be able to report on it later.

Female Breast.—I have recorded my experience in this domain on a number of occasions, and it has also been published in RADIOLOGY. My position differs somewhat from that of my colleagues, except Robert Greenough of Boston. I have had seven years' experience with pre-operative and post-operative X-ray treatment for breast lesions. I have given up post-operative radiation in all operable cases, whether or not the glands in the axilla are involved. I know, from statistical studies covering more than forty years, that when the glands are not involved, the probability of a five-year cure after operation is 70 per cent, and when the glands are involved microscopically, the percentages vary as follows: base glands 25 per cent; mid-glands 20 per cent; apex glands 10 per cent. If borderline tumors in which there is never metastasis to glands are included, the five-year cures in this group jump from 70 to 85 per cent. One can see at once how difficult—how impossible—it would be to estimate the value of pre- or post-operative radiation, or of both, in this group, unless the pathologic reports were accurate—not only as to the malignancy of the tumor, but as to the actual glandular involvement. Comparing this group, during seven years' study, with similar cases before and since, I can find no difference in the actual percentage of five-year cures. During these seven years, in addition to pre- and post-operative radiation, we employed, when the cancer of the breast was extensive, the cautery or the electric needle, known as endothermy or diathermy. Recently we have even given these up. This does not mean that we have given up radiation in cancer of the breast, but we reserve it for those cases in which there are signs of metastasis before or after operation. Its greatest value is in the relief of pain, especially in metastasis to the region of the vertebræ. Every now and then we encounter almost miraculous results. I have never seen a verified cancer in the breast show very much radiosensitivity.

At this time I have sufficient evidence to enable me to state that chronic cystic mastitis shows the same percentage of spontaneous recoveries, whether treated with radiation or not, and that pain in the breast and discharge from the nipple are not affected by radiation with X-rays or radium.

there were space and time to record here in greater detail exactly what has been accomplished by radiation for benign and malignant lesions of the breast. It can not be compared with the results obtained—and now well recognized and conceded—in cancer of the cervix and bleeding myoma of the uterus, and the value of checking the menstrual periods in older women on definite indications. Breast tumors, on the whole, are very slightly radiosensitive. In my own clinic, among every hundred women who seek advice because of some trouble or a lump in a breast, more than 65 per cent are not operated on. Much more than one-half of these breasts are lumpy. The most common pathologic process is chronic cystic mastitis, a condition which tends to spontaneous resolution. If all cases were subjected to radiation, one would erroneously conclude that there is a large number of radiosensitive tumors. Of the 35 per cent subjected to operation, more than 50 per cent are benign. If all definite lumps were radiated, it would be found that practically none of the benign lumps would show much change in the first two weeks, while many of the malignant lumps would show at least temporary decrease in size. If the observer decided to operate and used radiosensitivity for an indication, the indicated operation would be delayed in the most important group—that of cancer. Many of us, therefore, are waiting for the reports of the results of the treatment of lumps of the breast by radium alone in the hospitals of London and elsewhere.

When the lesion of the breast is clinically malignant and very extensive, it would seem best, and even definitely indicated, to try some form of radiation first; for example, in the group with skin metastasis, which is a sign that there is internal metastasis, whether it can be made out or not. Then there is a group called *cancer-en-cuirasse*. Years ago we never saw this in an operable case. Now I see, perhaps, one case out of every hundred, while it is still operable, even without glandular involvement. These cases have been given the most intensive and prolonged pre-operative radiation—none have been cured. Pain has been relieved, skin metastasis has disappeared (to return), there has been a wonderful mental effect, because the patients think something is being done for them. It will be very instructive and helpful when we have a large series of verified cases in which we can, in a cold-blooded sort of way, compare the operative group with and without radiation, with the group treated by radiation alone. Up to the present time I feel compelled to advocate surgery in all early and operable lesions, first ascertaining the nature of the tumor from frozen sections at biopsy, saving the breast when the lesion is benign, and performing the very best possible complete operation if the lump in the breast is cancer. My experience teaches me that it is a mistake, even when the tumor is minute, early, and microscopically cancer of any type, to remove the breast only and to depend upon radiation for the possible metastasis to the glands.

Paget's Disease of the Nipple.—I have published numerous statements, especially since 1921, concerning Paget's cancer of the nipple, and the treatment of the lesions of the nipple that are not cancer, but which may precede cancer. These can often be cured by simple cleanliness—frequent and thorough washing of the nipple with soap and water followed by alcohol, then covering with vaseline and protecting with a piece of gauze fixed by adhesive straps. There seems to be ample evidence that an irritation of the nipple in a woman over thirty, not nursing a child, has, if neglected, the same relation to cancer as the irritation of the nipple of a nursing mother has to mastitis. Both seem preventable diseases. Prevention comes with cleanliness and protection. It is the rule of the clinic to give these cases of irritation of the nipple, of whatever type, two or three weeks' trial of this treatment.

When there is no improvement, the patient goes to the hospital and is prepared for the complete operation. The nipple is excised under local anesthesia. If the frozen section shows malignancy, the complete operation is performed: if not, the breast is saved. Removal of the nipple and saving the breast is less mutilating and requires a less extensive operation than removing the breast and leaving the nipple.

I have had the opportunity to observe irritation of the nipple which failed to clear up when treated by X-rays or radium, yet returned to normal after treatment with soap and water. In the cases which were not affected by either, the exploratory excision of the nipple disclosed a benign or a malignant tumor. At the present moment it seems dangerous to try radiation for irritation of the nipple, as it may put off the operation when the lesion is malignant. One can be quite sure that soap and water will have very little effect on a malignant lesion. Unfortunately most forms of malignant disease are slightly radiosensitive and show temporary improvement and for this reason put off the necessary operation. If the patient wishes to run the risk in an irritation or ulcer of the nipple, I employ radiation when soap and water have failed. Of course, it can be tried first. It should be stated here that cancer of the nipple of the Paget type, without involvement of the deeper ducts or breast, may metastasize to the axilla.

Irritations of the Skin.—There are on the skin in any part of the body isolated areas of irritation, not unlike Paget's disease of the nipple. The most common is included under the term *keratosis,* which is microscopically a wart or an area of hypertrophied epidermis. Some are better described as scaly areas, like psoriasis; others are minute ulcers covered with a scab. There may be multiple areas of this kind, most commonly seen in the hairy parts. Then there is the little furuncle and the fever blister, and the single hair-follicle infection. In the past five years I have had a huge experience with such areas, in the treatment of which I have followed the same line as for irritated nipple. If the lesion does not disappear quickly under soap and water, it is completely excised under local anesthesia, with the knife, cautery, or endothermy, according to size and location. It is surprising how frequently we find microscopic areas of beginning cancer, especially of the basal-cell type. Undoubtedly many of these areas, even the malignant, have been permanently cured by radiation, but as I have seen recurrences in this type not cured by radiation and yet permanently cured by excision, I believe proper surgery, checked at operation by frozen sections, promises greater certainty of a cure than any other method. It is impossible to differentiate a small area of hair-follicle infection from a basal-cell cancer. In the early stage there is no difference between the basal-cell and the spindle-cell cancer. It is well known that the basal-cell cancer is radiosensitive, and the spindle-cell cancer very much less so. The spindle-cell cancer of the mucous membrane, especially of the mouth, is more radiosensitive than the corresponding lesion of the skin. Most of the reports on early and small skin cancer claim 75 per cent of cures. Of course, some of these are not cancer—the majority are probably basal-cell cancers. My records show that complete excision checked by frozen sections to bring out not only the pathology, but also the margin, should never fail to cure. In recurrent lesions of the skin in which complete excision would be mutilating or impossible, the results in basal-cell cancer are almost miraculous, but the more scar tissue from previous treatment of any type, the less the probability of a permanent cure. When we educate individuals to report the moment they notice an irritation of the skin, and teach the people the necessity for care and cleanliness of the skin, it is my opinion that excision will be the operation of choice in early operable

lesions. But at the present time, due to ignorance and neglect and faulty first treatment, there is a very large number of recurrent cases in which radiation with and without the cautery, coagulation, or endothermy offers the only hope of permanent relief. These cases have locally passed the stage of excision, or complete excision means so much mutilation that radiation should be tried first.

Tumors of the Skin.—Definite tumors of the skin—moles, pigmented or not; fibroma molluscum, pigmented or not; nevi and angiomas of the size and shape of moles and warts; warts; subepidermal nodules which can be completely excised without mutilation—all of these are best removed by surgery. Nothing is gained by radiation. With the exception of the angiomatous tumors and some warts, none are radiosensitive. It is really more economical, safer, and—although this statement will be challenged—no more disfiguring than successful removal by radiation. There is no harm, so far as I know, in trying radiation first. With the exception of the pigmented mole, there is no danger in delay. The danger in pigmented moles is that malignancy and metastasis occur almost simultaneously, so that when a patient notices the enlargement of a mole, or weeping, not a moment should be lost in getting rid of the local growth. The metastasis from a malignant mole is rarely, if ever, influenced by radiation; nevertheless, it should be tried, as this is the only treatment that offers anything. The attitude, therefore, to the visible, palpable lesion of the skin is entirely different from the attitude toward the invisible and palpable tumor in the soft parts which I have discussed in the beginning of this paper.

THE CONTRIBUTIONS OF EXPERIMENTAL STUDIES TO RADIOTHERAPY

By FRANCIS CARTER WOOD, M.D.,
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ALL the earlier radiotherapy, both with radium and X-ray, was worked out solely on a rule of thumb basis. The reasons for and the conditions of filtration, both with radium and X-ray, were but little understood, and the quantity of radiation necessary to be effective was also practically a matter of guesswork. No studies were in existence at that time concerning the relation between morphology and sensitivity. The first change in this situation was due to the work of Kroenig, Gauss, and Friedrich. The important monograph which they published in 1913 contained an immense amount of valuable experimental work done both on human beings and on biological material, such as tadpoles and frogs' eggs. At that time the conditions of measurement of X-ray and radium were rather crude, but important principles were laid down, one of which was that the effect of X-ray was independent of the wave length. The inverse square law was shown to apply, and the factor of time multiplied by intensity was shown to be true over a considerable period; that is, the results are the same when the intensity of the dose is varied in a proportion of 1:8, providing the time is equally increased. Shortly after this Wood and Prime, from the Crocker Laboratory, showed that with radium at a constant distance the equation of the lethal curve plotted with the percentage of takes of tumor particles as ordinates, and time as abscissæ was a simple curve of the pressure-volume type, provided the intensity remained the same. These writers also showed that there is a threshold below which no effect is obtained. The observations were made on both beta and gamma rays together, and also for gamma rays alone. They showed that there is no temperature coefficient observable with tumor cells between incubator temperatures, room temperatures, and 0° C. In other words, they demonstrated that a small quantity of radium over a longer period was fully equivalent to a larger quantity over a shorter period, and this was done on tumor particles. An interesting by-product of this observation was that the tumor after cultivation in animals for a period of thirteen years showed exactly the same death-point with the same radium set-up as it did at the time of the original experiments in the years 1913-14. The large number of tumor particles used and the large number of animals employed rendered the opinion of Wood and Prime unassailable from the statistical standpoint, at least as regards the exposure of tumor particles *in vitro*. The experiments were much more extensive than those of Kroenig and Gauss and confirmed on a different biological material the latters' results in every respect. Attention was called by Wood and Prime at that time to the fact that very large doses of radiation were required to destroy all the living tumor cells; in other words, to prevent growth after re-inoculation into a normal animal. During the War, Wood and Prime continued their work with X-ray, using as a means of measurement an open ionization chamber of the type originally devised by Perrin and improved by Duane. Their work was rendered much more accurate by the construction and employment of an apparatus giving a continuous current of X-ray. Under the conditions of generation of this X-ray the voltage and current through the tube could be very accurately determined and continuous readings could be made by the ionization chamber, using a sensitive galvanometer. All of these

experiments were done with particles suspended on thin gauze so as to avoid any scatter factor.

The publication of the doses of X-ray required to kill all the cells of a tumor was immediately challenged by all practical workers with X-ray. At the same time some very naive experiments were done in Germany by Kok, Keysser and others, in which tumor particles were exposed and injected into a few animals. Nothing was known about the percentage of takes of these tumors; they had not been under careful observation for any period of time; the measurements of the X-ray were very carelessly made, and the announcement was published that it was impossible to kill animal cancer cells with X-ray, while at the same time these writers were assuring the public that they could cure human cancers with very much smaller doses. The practical man resented the statement that five erythema doses are required to kill all the cells of a tumor, pointing out that he was obtaining clinical cures on rare occasions with smaller doses. Even those whose position warranted their being considered as authorities on the subject said that if these doses were correct, all effective radiotherapy would be impossible.

The last few years have done much to clear up the situation. Despite the fact that Wood and Prime called attention to the dosage being without scatter, and that scatter increased the dose, depending somewhat on the wave length (as much as 50 per cent), the importance of the scatter factor was not appreciated. Nor was it appreciated that a clinical cure can be obtained without destroying all the cells of a tumor. The study of late recurrences following apparent radiation cures and the examination of biopsy material removed from healed basal-celled tumors reveal only too often the presence of viable cancer cells. The occasional unfortunate results which have followed the removal of the uterus after a prolonged remission following radium treatment has also emphasized the fact that viable cancer cells may remain in the scarred tissues and be released to cause the death of the patient where surgery is undertaken even three to five years after the disappearance of the growth. The utter ineffectiveness of radiation in certain types of tumors has forced the recognition of the facts which were long since published on animal tumors, that is, that many of the human tumors require from five to ten erythemas to destroy all the cells and prevent recurrence. The spectacular results which have been obtained with the basal-celled tumors of the face and the carcinomas of the cervix are due in large part to the radiosensitivity of the cells in these regions. Most of the types of cancer require very much larger doses and their curability is consequently considerably less and can be achieved only under favorable conditions and with the administration of enormous quantities of radiation. The technic of this administration has become just as difficult and as complex as that of high grade surgery. Studies made on tumors of the cervix, and the fact that the squamous-cell tumors of the skin are very much more sensitive than the basal-celled type, call attention to the importance of morphology as in some sense giving a clue to the biological qualities of the cells themselves.

The introduction of grading by Broders, of the Mayo Clinic, caught the fancy of the surgeon and the radiologist, and a great deal of study has been done in attempting to correlate morphology with radiation sensitiveness. This was never Broders' original intention. He was grading on the basis of surgical cures—a very different question. Despite a large amount of work, there is considerable evidence that morphology does not give a very accurate measure of the radiation sensitivity of a tumor. In other words, as Woglom showed years ago, a mouse may have three breast tumors, all of

the same morphology, but these tumors may have a vastly differing biological malignancy, as measured by the percentage of successful inoculations. Out of all the confusion we can safely say to-day only that basal-celled tumors of the skin are sensitive, that the squamous-cell tumors are resistent, while the mixed types lie between, and that the most malignant and least differentiated cervical tumors are those which are most sensitive to radiation, while in general highly differentiated epithelial tumors are not especially sensitive. Nevertheless, in some regions, as Regaud has shown, a successful attack can be made on epidermoid carcinomata of the tongue, cheek, lip, and larynx, but as yet these results are far from controlling effectively cancer in these localities.

The next step was to determine the relation between wave length and lethal effect. Most of the papers have come from the Crocker Laboratory. Wood and his associate, Packard, have published a series of papers, Wood using animal tumors, and Packard the eggs of the fruit fly *Drosophila,* with the result that with an accurately measured, continuous current, the lethal effect is independent of the wave length, provided that the X-ray measurements are made with an open ionization chamber. The original results were obtained for tumor cells. Packard immediately repeated the work on *Drosophila* eggs and found that the same law held. He has since repeated these experiments with the gamma rays of radium and with the Bucky long wave length "Grenz" rays, and finds that the curve of killing of the *Drosophila* eggs is exactly the same with all three lengths. In the case of radium, only gamma rays were used, the filtration being 3 mm. lead. It is impossible to obtain quantitative measurements on these gamma rays in terms of roentgen units, so that a quantitative demonstration of the equality of these wave lengths has not been obtained. The form of the curve, however, is the same, and the dosage as estimated by erythema on the human skin is also nearly the same with X-rays and with the radium used. However, until it is possible to measure the gamma rays of radium and the X-rays, both in terms of the same unit, it will not be possible to show that the extremely short gamma rays are quantitatively the same as the X-rays in their biological effect. The laws governing the rate of killing which are expressed in the curves which Packard has published are, however, exactly the same. None of the small ionization chambers which are used for dosage measurement can be calibrated in terms of roentgen units, and then applied to the measurement of radium, and while it is probably true that the doses measured are in the same units, it has not been proved, because we have no way of measuring the very faint radiations from radium in an open chamber. Because a chamber is independent of the wave length from 0.6 to 0.2 Å., it is a pure assumption to state that it is also independent of the wave length 0.05 Å. Such accurate comparative measurements await the development of more sensitive apparatus but it is one of the fundamental problems in radiation measurement. The final problem is the determination of the relation between the energy of X-rays or gamma rays absorbed in the tissues and that absorbed in the ionization chamber; in other words, does the open ionization chamber measure the energy of the X-ray beam or does it not? When that is determined, we will know whether the destructive effect of radiation rests solely on the amount absorbed. No physicist will deny that in all probability it is only that absorbed which is effective, and that the effect is directly proportional to the amount of radiation absorbed, but the proof is still lacking. Interesting confirmations of these experiments of Wood's and Packard's on tumor cells and *Drosophila* eggs have been obtained by Fricke and Morse using hemoglobin solutions and certain iron salts. Independence of the wave length was ol

experiments were done with particles suspended on thin gauze so as to avoid any scatter factor.

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ROENTGEN DIAGNOSIS AND TREATMENT OF THYMOMATA[1]

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PRIMARY tumors of the thymus, as a group, have not been recognized clinically in as large numbers, in the past, as they should have been if all the diagnostic measures had been employed. A perusal of the literature of this subject discloses the fact that a large percentage of the cases came to the autopsy table without a correct diagnosis having been made and many of the cases had not even had a roentgenographic study of the chest. Much of the literature is concerned with discussion of the pathology of these tumors, especially as to the origin of the small lymphocyte-like cells found in the parenchyma. This uncertainty as to the exact origin of these cells has led to the word "thymoma" being employed to designate certain tumors which in general resemble lymphosarcomata.

These tumors are relatively uncommon but apparently not so rare as the literature would indicate. Approximately one hundred cases of primary thymic tumors have been reported, of which less than twenty were carcinomata and practically all the remainder were sarcomata.

ANATOMY

The thymus is a paired organ arising from the third bronchial clefts. It occupies the anterior and superior mediastinum and varies in size according to the age and general condition of the health. It may be so large as to fill the available space between the pleural sacs laterally, the sternum anteriorly, and the pericardium and great vessels posteriorly. On the other hand, it may be so small that it is found with difficulty at the postmortem table. Its shape is determined by its size and by the structures with which it is in intimate contact.

There is a fibrous capsule which sends septa into the substance of the gland, thus dividing it into lobules which are, in turn, subdivided into follicles. These follicles consist of medulla and cortex. The structure of the cortex resembles lymph gland structure, except that the reticulum instead of being fibrous is syncytial. The spaces of the reticulum are crowded with lymphocytes. The medulla resembles the cortex, but the reticulum is coarser and contains cell nests, the concentric corpuscles of Hassall.

PATHOLOGY

Primary thymic tumors, according to Ewing (1), may be classified as follows:

(1) Lymphosarcoma or thymoma, composed of a diffuse growth of round, polyhedral, and giant cells. The chief source of this tumor is probably the reticulum cell, but lymphocytes are often present in abundance.
(2) Carcinoma arising from the reticulum cells.
(3) To these may be added very rare and somewhat questionable cases of tumors attributed to the stroma and called spindle-cell or myxosarcoma.

When the chest is opened at the postmortem table a mass is seen occupying the region of the thymus. This may be round or triangular in shape, lying in the anterior mediastinum, and is usually yellowish or grayish in color. It may be encapsulated but is frequently adherent to the sternum and surrounding organs, and may invade the pericardium, pleura, lungs, trachea, and glands. Direct invasion is more often seen than distant metastases. Metastases below

[1]Read before the Radiological Society of North America, at the Fifteenth Annual Meeting, at Toronto, Dec. 2–6, 1929.

the diaphragm have been reported in approximately five cases previous to this, according to Herriman and Rahte (26), and the site of predilection for these abdominal metastases is the kidney (2). Bone metastases have been reported, as well as metastases to the brain and most of the other vital organs. Perforation of the chest wall has been found in at least two cases. The axillary and cervical glands are frequently found to be involved, and enlargement of these glands should call for early roentgenographic examination of the chest.

The lymphosarcomata of the thymus are described as being of two groups. The first and most common is composed of small round cells arranged diffusely or lying in groups with a delicate connective tissue framework. The blood vessels may be numerous and in some cases the cells may form sheaths about the vessels, suggesting a perithelioma. The second group gives the picture of infectious granuloma suggesting Hodgkin's disease. It is composed of lymphocytes, plasma cells, and large polyhedral cells which are apparently derived from the reticulum. The lymphocytes may be very scanty.

Ewing (1) states that on close analysis the round-cell tumors of the thymus mentioned above are different from the round-cell tumors of lymph nodes.

> "The lymphocytes are scanty. The chief cell showing mitosis is often polyhedral, with acidophile cytoplasm, vesicular nucleus, and well-developed nucleoli. They often cling to the walls of numerous small capillaries where they assume a cubical or even cylindrical form. They may produce Hassall's corpuscles. The giant-cells are of two main types: (1) pale staining reticulum cells with irregular outlines, distended with vacuoles and red cell detritus, and (2) myeloid giant-cells with opaque acidophile cytoplasm and many vesicular nuclei. These giant-cells differ from the smaller giant-cells of lymphatic Hodgkin's disease."

The carcinomata of the thymus are much rarer than the round-cell sarcomata. Brannan (16) reports that he has found only fifteen cases of undoubted carcinoma reported in the literature and to these he adds one case. He also gives a good summary of these reported cases. They are less likely to metastasize than are the carcinomata of most other areas and invade surrounding structures somewhat less actively. Foot (12) states that "the tumor is of a definitely epithelial type; its cells correspond to those of a loosely built alveolar carcinoma, but differ from them inasmuch as they are stellate and more like embryonal thymic reticulum cells, and also because they tend to form bodies that resemble thymic corpuscles more closely than the epithelial 'pearls' of an epidermoid carcinoma."

CLINICAL FINDINGS

The clinical findings vary according to the type and extent of the growth at the time the patient is first seen. Cough and hoarseness are among the earliest symptoms in many cases, and several cases are reported by Janeway (3), Jacobson (4), and others in which the condition was first diagnosed as tuberculosis. Weakness, loss of weight, and pain in the neck and chest are also prominent early symptoms. Dysphagia and a sense of pressure in the upper chest may also be complaints. Pain and tingling of the shoulder and arm are minor complaints.

Later in the course of the disease, if uninfluenced by therapy, the foregoing symptoms may become extreme and, in addition, there is frequently compression of the great vessels, with resultant venous congestion of the upper chest, neck, and head, including bulging of the eyes. Pleural and pulmonary involvement, together with hydrothorax, also may complicate the picture. Extension through the anterior chest wall is mentioned by Ewing (1) and Janeway (3). Several cases of lymphatic leukemia have been reported in conjunction with thymoma.

Enlargement of the axillary lymph nodes

is a common finding and in many cases is out of proportion to the cervical lymph node involvement. Ewing (1) says that "tumors of the axillary nodes without known origin should call for investigation of the thymus by the X-ray, especially before any operation is attempted on the axilla."

Physical examination of the chest may reveal retrosternal dullness, with clear apices and lung fields, but in many of the reported cases, and in most of our cases, the mass was not suspected from the clinical examination during the early course of the disease.

ROENTGEN FINDINGS

It is apparent that the greatest reliance in diagnosis must be based on the X-ray findings since the physical findings are not constant or reliable in these cases. The X-ray appearance, in a typical case, is characteristic and consists of a more or less circular, sharply defined, non-pulsating shadow lying just above the cardiac shadow in the position ordinarily occupied by the thymus gland. Films in the lateral position show it occupying the anterior mediastinum. It may, however, project more to one side and not be symmetrically placed and in some cases it is irregular in outline. Fluoroscopic examination is valuable in ruling out aortic aneurysm.

In some cases, especially in the advanced ones, there may be extension to the pleura or lungs, with haziness of the lung fields so that the circumscribed tumor cannot be seen. Other types of mediastinal tumors are likely to be found higher up in the mediastinum and may occupy the middle and posterior portions of the mediastinum.

Aortic aneurysm may be differentiated from this condition by the fluoroscopic finding of the characteristic aneurysmal pulsation and often by its position. The combined roentgenographic and roentgenoscopic examinations should practically always differentiate these two conditions.

Mediastinal abscess may give a shadow similar to thymoma but is not likely to lie entirely in the anterior mediastinum. This should, however, be differentiated by the clinical findings, such as history, leukocytosis, and fever.

Chronic mediastinitis sometimes is shown by a diffuse widening of the mediastinum but more often by an irregular contour revealing evidence of pleural adhesions and glandular enlargement. It sometimes shows evidence of bronchiectasis in the vicinity.

Substernal thyroid is found higher in the mediastinum and the shadow is continuous with the thyroid shadow in the neck. The patient also usually gives clinical evidence of hyperthyroidism.

Various cases have been reported in the literature (3 and 4) in which the diagnosis of tuberculosis was first made before the true condition was suspected. This should practically never occur if the patient is given the benefit of roentgenographic examination of the chest.

Lymphosarcoma and Hodgkin's, while often occupying a different position, may almost exactly duplicate the shadow produced by thymoma, and they may be rather difficult to differentiate. Hodgkin's is more likely to show invasive characteristics than is the true thymoma. Differentiation here is not of great practical importance, as radiation therapy is recognized as the best treatment for both conditions.

RADIATION THERAPY

Radiation therapy is the method of choice in the treatment of this condition for several reasons: (1) This region is almost inaccessible for any thorough operative extirpation; (2) in a large percentage of the cases the disease, when recognized, is no longer a local condition but has already metastasized to distant areas or has invc the adjacent structures by local



Fig. 1 Case 1 Large rounded tumor shadow before X-ray therapy (Aug 9, 1924).



Fig 2 Same case, showing regression of tumor after X-ray therapy (1929).

(3) these tumors are quite sensitive to radiation therapy.

The biological results from the use of X-ray and radium are for practical purposes the same, so that the problem as to the use of either largely resolves itself into a question as to the relative availability of these two methods of treatment. Unfortunately only a very few medical centers control enough radium to make therapy of the deeper structures available, while almost all hospitals and roentgenologists are equipped to give adequate X-ray therapy to this type of case. We shall confine our discussion to the roentgen method.

It has been our practice to use 185 kilovolts, 50 cm. F.S.D., 0.5 mm. of copper plus 1.0 mm. of aluminum filtration as the basic factors. The depth dose is then calculated with the aid of depth dosage charts, and an attempt is made to deliver to the tumor from 75 to 90 per cent of a skin unit dose. A similar dose is delivered to the metastases wherever found, but no attempt is made to treat the entire lymphatic system and abdominal organs, owing to the severe reactions following such treatment and to the fact that these tumors have a tendency to remain localized to the chest, axillæ, and supraclavicular areas. The lungs are shielded as much as possible to prevent fibrosis, and special attention is taken to protect the heart, as it has been shown experimentally and clinically by Hartman, Bolliger, Doub, and Smith (10) that irreparable damage may be done to the heart by excessive radiation over that organ.

The regression in size of these tumors is quite satisfactory but somewhat slower than is seen in the case of the ordinary lymphosarcoma. Entire disappearance of the tumor is frequently accomplished only after

the administration of more than one course of treatments, although it commonly regresses to a remarkable degree after a single series. Usually the shadow of the tumor mass will have decreased in size about one-half in from one month to six weeks after the first series of treatments.

There is usually some constitutional reaction, of greater or lesser degree, following intensive irradiation. This will depend upon the intensity of the irradiation, the areas treated, and the toxins absorbed from the destroyed tumor. The symptoms are much the same as in any other case of radiation sickness and vary from mild discomfort and slight nausea to extreme nausea, vomiting, aversion to food, and general prostration. These symptoms have been described more fully in a previous communication (11). A pronounced leukopenia or anemia is often produced, especially in those patients whose entire lymphatic system has been irradiated, and this may be so severe as to require repeated blood transfusions. In the ordinary case there is a return to normal in from six weeks to two months, but in extreme cases, unless blood transfusions are given, there may be a convalescence extending over many months.

Careful medical management, with special attention to reëstablishment of the normal blood level, the stimulation of the eliminatory processes, and the building up of the patient by dietary measures will contribute greatly to his general welfare.

CASE REPORTS

Case 1. C. K., male, aged 38, was admitted August 9, 1924, complaining of swollen glands in the neck and loss of 25 pounds in weight.

Physical examination revealed flatness extending to either side of the sternum, together with enlargement of the cervical, axillary, and inguinal glands.

X-ray examination of the chest disclosed a large rounded tumor mass measuring 16 cm. in diameter, extending out from either side of the mediastinum just below the clavicles. The chest was otherwise clear.

The pathological diagnosis following biopsy was: Metastatic lymphosarcoma—reticulum cell type (thymoma).

X-ray therapy was instituted immediately following this, using the following factors: 185 kilovolts, 0.75 mm. copper plus 1 mm. aluminum filtration, 50 cm. focal skin distance, 360 milliampere-minutes. In two weeks following cessation of the series of treatments there was a definite decrease in the size of the glands treated and a decrease of 3 centimeters in the width of the mediastinal tumor. In two months the superficial glands had disappeared and there was rather marked decrease in the size of the mediastinal tumor. The patient had gained 15 pounds in weight and felt in excellent health. Another course of treatments was given at that time. The patient has since that time had several relapses of the tumor, but has always responded quickly to treatment. The X-ray picture has been that of slight widening of the mediastinum, with an irregular margin. This picture in other cases has been found at postmortem examination to be associated with replacement of the tumor by fibrous tissue.

During all this time, the patient has been working, and he is quite free of symptoms at the present time.

Case 2. A. F., male, aged 39, was admitted in February, 1928, complaining of lumps in the neck. The symptoms dated back six months to a time when the patient had noticed a small gland above the right clavicle. During the past two weeks a mass had appeared beneath the middle third of the left sternomastoid muscle. There was also a mass beneath the right sternomastoid muscle which appeared to be attached to the trachea. The patient stated that it had been there for a long time, but had recently en-

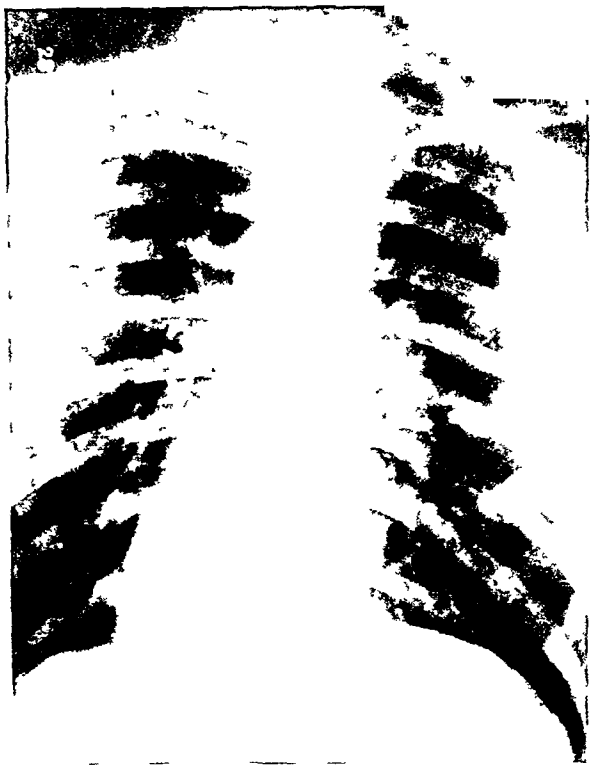


Fig 3. Case 2. Tumor shadow in mediastinum (slightly to right).

larged and become tender. There had been a loss of eight pounds in weight.

X-ray examination of the chest revealed a tuberculous focus in the apex and subclavicular area of the left lung. There was also a shadow of increased density seen in the mediastinum slightly more to the right side, which did not project very far to either side of the mediastinum, although the margins were smooth and clear-cut.

A gland was excised from the neck for microscopical examination Section of the gross specimen suggested Hodgkin's disease, while microscopical examination of the sections resulted in a diagnosis of thymoma, with extension to the glands of the neck.

The patient was then referred for deep X-ray therapy and, because of the respiratory embarrassment, was advised that tracheotomy might have to be done. The first series was started on February 23, 1928. The respiratory difficulty became so great that on February 27 it became necessary to do an emergency tracheotomy, which gave prompt relief. The patient continued to improve and the tracheotomy tube was removed after five months. At that time no evidence of the tumor shadow could be seen. The man has had three series of deep X-ray therapy in all and is clinically well up to the present and is taking care of his business. Repeated X-ray examinations of the chest have failed to show any evidence of return of the tumor shadow since that time.

Case 3. F S., male, aged 25, was admitted in January, 1929, with the complaint of pain in the chest, and hemoptysis two weeks before admission. He had lost 20 pounds in weight and also had lost strength.

Physical examination suggested impairment over the left upper lobe, and a few sticky moist râles in the left second interspace near the sternum.

X-rays of the chest revealed a tumor shadow extending outwards and upwards from the left hilum area, rather suggestive of lymphoblastoma.

Because of other clinical findings, a tentative diagnosis of tuberculosis was made, but repeated sputum examinations were negative for tubercle bacilli. The patient continued to cough and to have fever, so that bronchoscopy was done. The right bronchus was found to be normal. The left bronchus was reddened and at one point there was a slight amount of grayish exudate. A lung tumor was suggested. An exploratory operation was performed and a hard rounded tumor was found at the border of the left lung. From frozen section a diagnosis of sarcoma was made Permanent sections showed evidence of a tumor, suggesting carcinoma, and also evidence of thymic remains. Radium needles were implanted in the tumor at the time of operation and 640 milligram-hours were given with the bare platinum needles. Deep X-ray therapy was then given over the mediastinum to supplement the radium therapy.

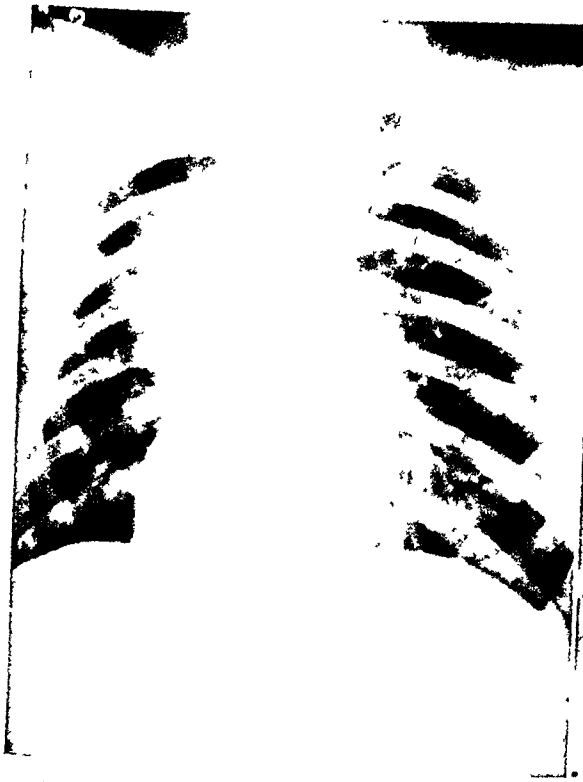


Fig. 4 Case 3. This shows a large tumor extending out from the left hilus area (Jan 26, 1929).

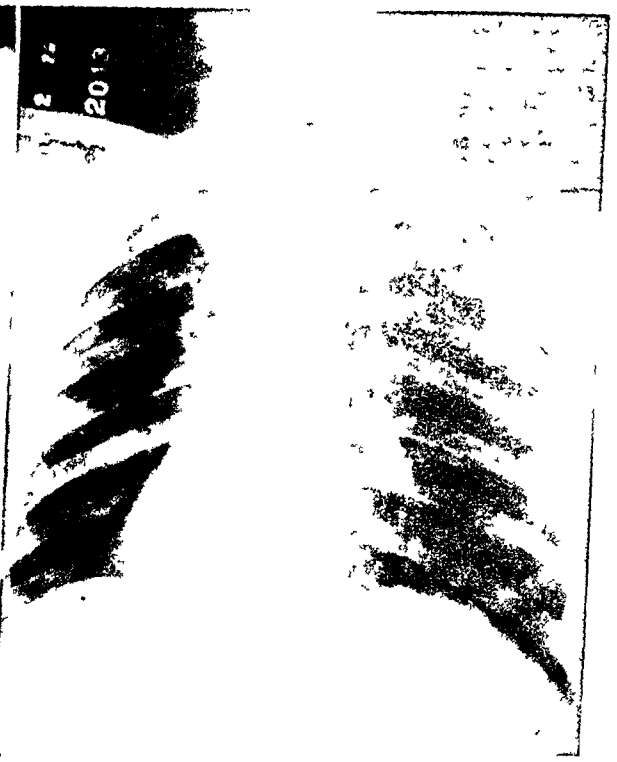


Fig 5 Same case as Figure 4, showing almost complete disappearance of the tumor after radiation therapy (Nov 2, 1929).

One month after this the patient had gained four and one-half pounds, was much stronger, had a good appetite, and had no chest pain. X-ray examination at this time showed very little change in the size of the tumor shadow. A second series of deep X-ray therapy was given two months after the first series. At this time the patient had gained thirteen pounds and the X-ray films of the chest showed the tumor to be about one-half of its original size. At the present time, the patient is feeling as well as usual and is able to attend to his work X-ray examination of the chest shows fibrosis at the site of the tumor. It is impossible to state definitely if there is any tumor tissue remaining or not.

Case 4. D. G., female, aged 37, was admitted in April, 1929, complaining of cough, shortness of breath, and inability to lie on her back or right side During the preceding six years the patient has noticed a general enlargement of the lymph glands, especially in the neck and under the arms During the Winter of 1928-29, she was troubled by colds and a tightness of the chest. Some fluid was removed from the right pleural cavity at that time

Physical examination revealed dullness over the right base, with restriction in the movement of the right diaphragm. There was also dullness extending laterally from the mediastinum. A mass in the abdomen lay to the right of the umbilicus Enlarged glands were found in the right cervical area and in both axillæ.

X-ray examination of the chest revealed a large tumor shadow in the mediastinum, lying almost entirely below the clavicles and merging with the cardiac shadow below. The edges of this were clear-cut and extended almost equally to either side There was also elevation of the right diaphragm, with infiltration of the right base and a very

small area of pneumothorax. A gland was excised from the axilla for examination. Gross section suggested lymphosarcoma. Microscopical examination resulted in the diagnosis of *thymoma, granulomatous type.*

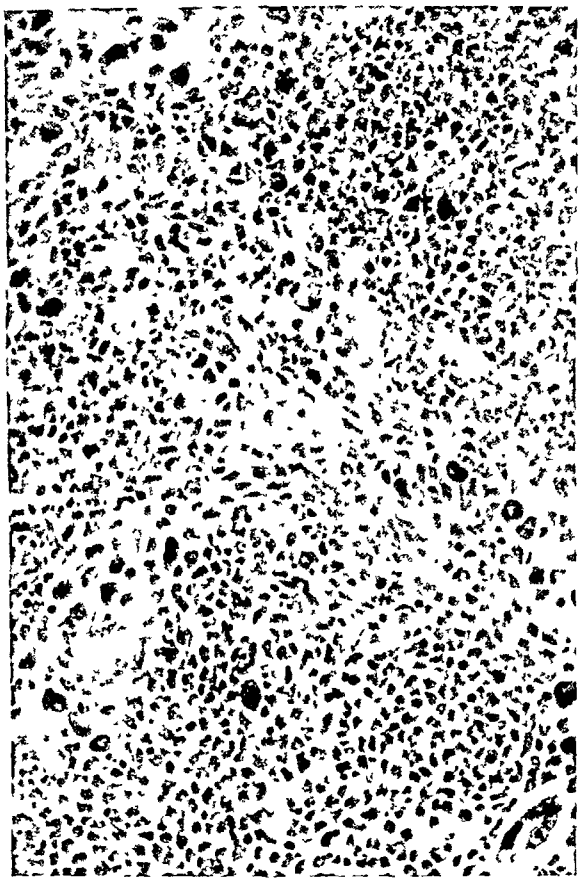


Fig 6 Case 3. Low power microphotograph showing multinucleated tumor giant-cells, small lymphocytes, abundant stroma, and structure suggesting Hassall's corpuscles in lower left corner of the picture.

The patient was given one series of deep X-ray therapy, May 16-20, 1929. Three months later she was feeling well, was working, and had gained eight pounds. There were still a few palpable glands. At the present time she is feeling in excellent health, working every day, and complains of no untoward symptoms. X-ray examination of the chest shows very little or no widening of the mediastinum. The right base has almost entirely cleared up.

Case 5. M. H., female, aged 32, was admitted in May, 1925, complaining of fever, weakness, and loss of weight. She gave a history of hospitalization for pulmonary tuberculosis for the past three months. The temperature has been quite irregular, reaching an elevation of 105.5°. Physical examination revealed an impaired resonance over both upper lobes, together with fine crepitant râles over the same areas.

X-ray examination of the chest showed evidence of extensive pulmonary tuberculosis of both upper lobes, especially the left, also a fairly large mediastinal tumor extending out to either side of this area—a shadow which lay mostly below the clavicles and partly over the cardiac shadow.

Because of inability clinically to rule out abscess of the mediastinum, it was decided to do an exploratory examination of this under local anesthesia. This was done, and the mediastinum was entered through the sternum at the level of the second costal cartilage. A thick, firm, lobulated mass resembling thymus tissue was disclosed, a portion of which was removed for microscopical examination. This was reported by the pathologist as malignant thymoma.

One course of deep X-ray therapy was given over the mediastinum, resulting in a decrease in the width of the mediastinum. The patient then returned to her home and death occurred about two months later. No postmortem examination was made.

Case 6. B. H., female, aged 72, was admitted in March, 1927, complaining of weakness, loss of appetite and strength. He present illness dated back six months, w weight loss of 30 pounds in that time. P cently she had had shortness of breath.

Physical examination showed an ol elderly woman with marked tremor. Ti was dullness at the base of the left and a triangular area of dullness to right of the spine. The heart and were enlarged. There was tendernes the epigastrium but no masses could be



Fig. 7. Case 4. Tumor of mediastinum, with involvement of base of right lung and elevation of right diaphragm. (Before X-ray therapy, April, 1929.)

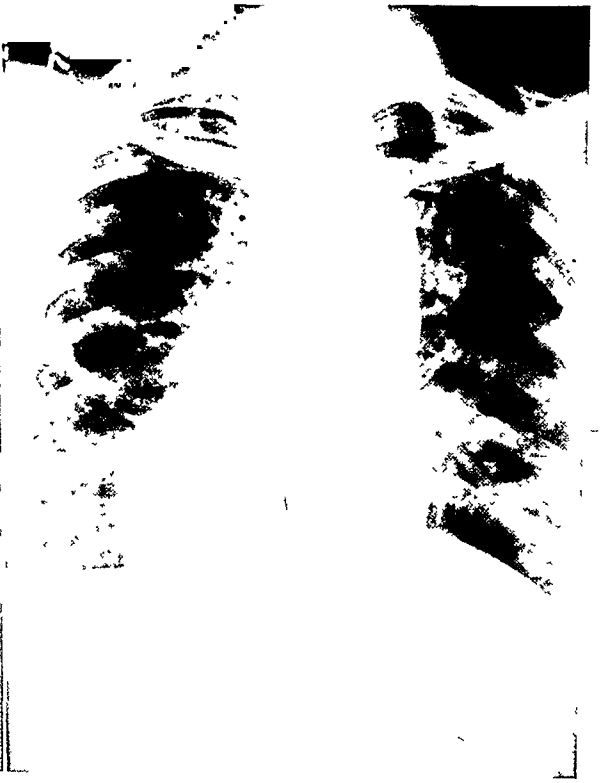


Fig. 8 Same case as Figure 7, showing regression of mediastinal tumor and clearing of right base. (After X-ray therapy, November, 1929.)

X-ray examination of the chest was made with the portable machine, but was not satisfactory owing to the patient's inability to hold her breath and to her general obesity. The films, however, did show fluid and thickened pleura in the left base and a general widening in the region of the heart and great vessels.

Fluid was removed from the left chest and microscopic examination of this showed many large cells with hyperplastic nuclei suggesting tumor cells. Fluid was again removed several days later. Death occurred from cardiac failure nine days after admission.

Postmortem examination disclosed an irregular, nodular tumor mass the size of a large orange in the upper anterior mediastinum. No thymic remains were found. The lymphoid tissue of the glands was replaced by light gray, translucent tumor tissue. Metastases to the pleura, mediastinal, mesenteric, and retroperitoneal lymph glands were found. There were also metastases to the spleen, pancreas, and peritoneum. The microscopic diagnosis was thymoma with metastases. There was also dilatation of the heart, with chronic passive congestion of the liver and spleen. The lungs showed pulmonary embolism.

DISCUSSION

In reviewing the literature one is struck by the number of cases in which the diagnosis was first made at the autopsy table. In many cases the patient had not been given the benefit of radiographic examination of the chest. Several cases are reported, however, in which the X-ray picture was not

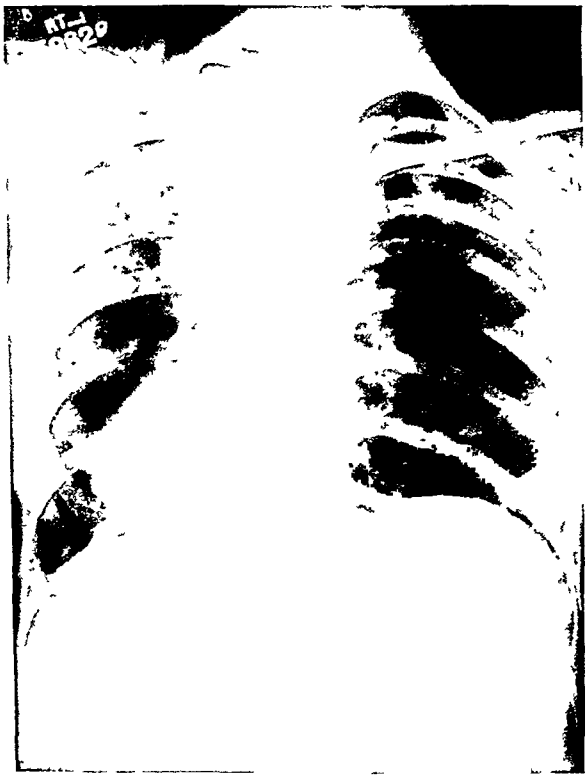


Fig 9 Case 5 Large mediastinal tumor showing clear-cut borders Pulmonary tuberculosis of both upper lobes.

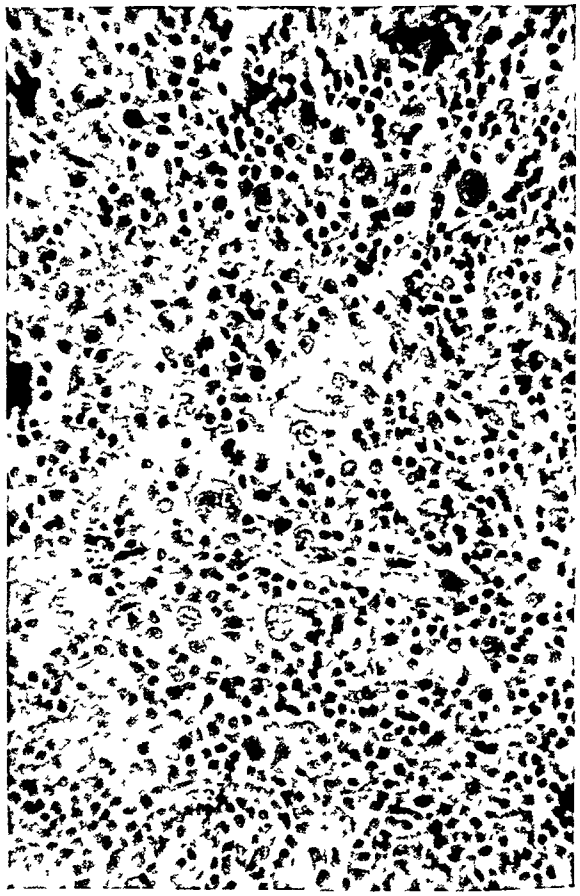


Fig 10 Case 5 Low power microphotograph showing multinucleated tumor giant-cells, lymphocytes, and reticulum cells supported by delicate fibrous stroma.

conclusive. Jacobson (4) reported a case in which the early roentgenologic appearance suggested tuberculosis Foot and Harrington (13) reported a case of an infant in which the tumor spread out over the left side, causing compression and destruction of the lung and producing a shadow which was interpreted as being an enlarged heart. Noice (14) reported the case of a child, aged four years, in which a pleural effusion so clouded the picture that the tumor shadow was not seen. Evert (15) reported a case in which the radiograph of the chest did not show the tumor of the mediastinum, but did show metastases through the lungs which gave the appearance of miliary tuberculosis. In Brannan's (16) case tuberculosis was first diagnosed, but shortly before death a tumor of the mediastinum was shown by the X-ray. In our cases the tumor shadow was easily made out in each case, but in several instances we were not able to state definitely the character of the tumor until microscopic examination had been done. It is apparent, therefore, that the radiographic examination of the chest is the diagnostic measure which is most apt to disclose the presence of thymomata. If the differential diagnosis can not then be made, a microscopic examination of a gland or of the original tumor should be made.

Somewhat more than a hundred cases have been reported up to date and of these approximately twenty were carcinomata. It is difficult to give the exact number owing to confusion in the terminology. Brannan (16) reviewed the literature in 1926 and found sixteen authentic cases Several more have been reported since that date.

Symmers and Vance (17) objected to the term "thymomata" being used except in the case of those tumors which faithfully reproduce the structure of the thymus as a whole, including lymphocytes, epithelial reticulum cells, and Hassall's bodies. This name has come to be used partly because of the disagreement as to the origin of the small lymphoid cells and partly because these tumors do tend to reproduce the structure of the thymus gland and have clinical and pathological differences from lymphosarcoma of lymph glands.

Bell (18) reports a case of myasthenia gravis that had an associated tumor of the thymus, and Mella (19) states that this is a syndrome and not a disease entity. He says that the myasthenia gravis may disappear after irradiation of the thymic area.

Lymphatic leukemia has also been reported in association with thymoma. Major (20) has reported a case in which he believes the thymic condition to be evidence of disease of the lymphatic system which later manifested itself by the appearance of acute lymphatic leukemia. Friedlander and Foot (21), also Young and Spalding (22) have reported similar cases. In the latters' case the disease developed suddenly while under observation. Evans and Leucutia (23) have also reported three cases of lymphatic lymphosarcoma which terminated in lymphatic leukemia. They believe that this occurs as soon as the lymphosarcomatous involvement of the bone marrow becomes the predominating feature of the disease.

Several cases have been reported in infants and children. Renault, Cathala, and Plichet (24) reported a case of an infant aged twenty months in which death occurred from suffocation nine months after the first symptoms had been noted. Foot and Harrington (13) reported a case of an infant with an epithelial tumor, which is uncommon. They believe that this substantiates the theory that thymomata not only arise from thymic reticulum, but may present a picture that is strikingly like normal embryonic thymus at an early stage of its development.

Gandy and Piedelievre (25) reported a case which suddenly developed symptoms of obstruction of the superior vena cava. Death took place twelve days later. Harvier (7) also reported a case in which thrombosis and obstruction of the superior vena cava occurred. Foot (12) and Brannan (16) have reported cases in which death was caused by hemorrhage from invasion of a bronchus. In Brannan's case the tumor filled the lumen of the superior vena cava and closed the orifice of the azygos vein while both innominates, both jugulars, and the right subclavian veins were thrombosed. This involvement of the large vessels is one of the features that have not been stressed sufficiently.

In attempting to estimate the life expectancy of these patients who have had radiation therapy one is handicapped by the paucity of the literature on this subject. Janeway (3) reported the cases of nine patients who had had radium therapy: six of them died at intervals of from ten days to two years and five months following irradiation. The remaining three patients were alive and well at the time of the report, having received their first irradiation previously at the following intervals: (1) one month, (2) eleven months, and (3) fifteen months.

Dwyer (5) reported the case of one patient who had been treated with X-ray therapy and who was alive and in good health at the time of the report (three years later). Groover, Christie, Merritt, and Coe (6) reported two patients who had had X-ray therapy and were alive and well five and nine months, respectively, afterward. Pool (8) reported one patient who was alive ten months after X-ray therapy.

We have treated five proven cases of thymoma with X-ray therapy. One patient

received but one treatment and showed some regression of the tumor but died at home two months later. This case had extensive tuberculosis of the lungs. The other four patients are alive and well at the present time, at the following time intervals since their first treatment: (1) five years and four months; (2) one year and ten months; (3) eleven months; (4) eight months.

It is obviously too early to give any prognosis as to how permanent this benefit is going to be. However, from the uniformly good results which have been obtained from the use of X-ray therapy we believe it can be stated that these cases are quite sensitive to radiation therapy and that from its use one may expect favorable results in a high percentage of cases.

SUMMARY

1. In too large a percentage of cases in the past primary tumors of the thymus have been unrecognized before going to autopsy.

2. These cases are uncommon, but not so rare as has been thought in the past.

3. The sarcomatous type of tumor predominates but a carcinomatous type also occurs.

4. These tumors are difficult to differentiate by the ordinary clinical methods.

5. Roentgenographic examination of the chest shows this tumor as a more or less circular, sharply defined, non-pulsating mass occupying the anterior mediastinum. This method of examination is also valuable in differential diagnosis.

6. X-ray therapy is indicated in these cases as soon as the diagnosis is made. These tumors are quite sensitive to radiation therapy and prompt regression of the growth can usually be expected.

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DISCUSSION

DR. P. M. HICKEY (Ann Arbor, Michigan): I have nothing to add especially, except to report one case which we saw recently; I will read the clinical notes. The patient was a white male, five years of age, and was brought to the hospital on Nov. 11, 1929, by his mother with complaint of progressive loss of weight. The family and past histories were negative. The present illness began six weeks before admission; the child had a severe cold and coughed a great deal. The parents were not certain as to whether or not he had pneumonia at that time. He was seen by a physician, who thought the chest was filled with fluid and attempted aspiration, obtaining a small amount of bloody fluid. Since that time there had been progressive loss of weight, the child being markedly emaciated at the time of admission. An X-ray examination had been made at Albion and three attempts at paracentesis apparently failed to reveal any fluid. At this time the parents were told that the child had a tumor mass. The anterior-posterior diameter of the chest appeared to be enlarged; there was very little excursion on respiration; marked fullness and flatness over both sides anteriorly except for small areas in each base and apex. Posteriorly there was dullness over the apices, extending downward to a point opposite the point of the scapula. Breath sounds were extremely dyspneic and heart sounds were heard with great difficulty. There were a few râles in the left scapular region. Liver margin palpable 5 finger breadths below the right costal margin and extending to the left of the midline. The kidneys were palpable, enlarged and hard, particularly on the left. There was moderate adenitis in the left axillary and inguinal regions, also on both sides of the neck. The laboratory findings were as follows: hemoglobin 70 per cent; 26,000 white blood corpuscles, of which 52 per cent were polymorphonuclears, 22 per cent small and 26 per cent large lymphocytes, and some nucleated red cells. Biopsy was done of the cervical glands on Nov. 15, 1929, the findings suggesting lymphosarcoma. X-ray examinations of the chest were made on Nov. 11 and Nov. 14, 1929. I might say that the clinical diagnosis which was suggested was pericardial effusion. We made a tentative diagnosis of bilateral thymoma. This was confirmed by the biopsy on one of the enlarged glands in the neck. The child died after he had been in the hospital three or four days, and on that account therapy, which had been recommended, was not carried out. This is the appearance found both in the antero-posterior and postero-anterior positions. I would like to call your attention to this axillary line, which we were quite at a loss to explain. The lateral plate shows the shadow



Fig. 1. See discussion by P. M. Hickey, M.D., of paper by H. P. Doub, M.D.

of the tumor mass anterior to the trachea. Autopsy was performed three or four days later, after these films were made, and this mass was found to be enormously enlarged and very much infiltrated. You could make out both lobes of the thymus and also the isthmus. The shadow on one side down in the angle of the pleural cavity was found to be a string of lymphosarcomatous cells deposited in the pleura. There were lymphosarcomatous cells on the pericardium and also infiltrating both kidneys.

I think in these cases we are quite wrong if we say that the growth has its origin in the thymus. In such cases the individual has a diathesis or systemic condition in which there may be the development of lymphosarcomatous cells in any of the lymphoid tissues; if they happen to predominate in the thymus, perhaps it is not quite correct to speak of the condition as a thymoma.

Another case to which I would invite your attention is that of a young woman who had been treated for lymphoblastoma. She had a very peculiar shadow in the upper right lung field, which we were regarding as perhaps one of the manifestations of a Hodgkin's, but at autopsy there was found to be a dislocated thymus which was intensely infiltrated with these lymphosarcomatous cells.

I would like to congratulate Dr. Doub on the presentation of his paper and the very good survey he made of the literature.

DR. GEORGE E. PFAHLER (Philadelphia): Dr. Hickey's slide reminds me of a case that I have referred to as having gone through a most interesting cycle of history. Two years ago the child was eleven years of age; two years previously he had developed enlarged lymph nodes in the neck. One of them was incised, and diagnosed as a tuberculous lymph node. These nodes disappeared temporarily, but recurred, and two years after this experience, the child was brought to me with a picture almost an exact duplicate of the one Dr. Hickey has shown on the screen. I made a diagnosis of Hodgkin's disease, because there were associated some lymph nodes in the neck—not very large, probably two or at most three centimeters in diameter—and very small lymph nodes in the axilla. I gave this patient a 15 per cent dose of high voltage rays, and the child almost died. He became so ill with the rise in temperature, diarrhea, vomiting, and inability to take any food, that I called in a gastro-enterologist to help me, and it was two weeks before I could give the child any other treatment. At that time the tumors in the chest had disappeared as well as nearly all the other lymph nodes. Then the latter began to enlarge, another was taken out of the neck, sections were studied microscopically, and the diagnosis of lymphosarcoma was made. It is true the pathologist had no history — simply the specimen. We then started very slowly and with very little extra treatment over these lymph nodes, but without any success. The

child developed a progressive enlargement of the thymus, again almost to the size shown at first, followed by enlargement of the other lymph nodes, and enlargement of the liver and spleen to a degree that almost filled the abdomen. About this time he developed a typical picture of lymphatic leukemia, and died. At autopsy a diagnosis of thymoma was made, associated with lymphatic leukemia. There is a case of a child who went through the whole gamut—four diagnoses, three of them, at least, microscopic.

DR. LESTER A. SMITH (Indianapolis): Recently we had quite an unusual case at the Indiana University Hospitals. According to the experience of Dr. Doub, the clinical course and the X-ray appearance of the chest are those of thymoma. While this had not been the clinical diagnosis during life, the microscopical appearance of tissue from both the mediastinal tumor and a bone metastasis was that of thymoma. The patient was a girl three years of age who entered the hospital on account of a dyspnea which had been gradually increasing over a period of two or three months. There was right exophthalmos, and left cervical and supraclavicular adenopathy had been present for two years. The first X-ray examination was not very satisfactory, the patient being almost moribund, but films made immediately after the postmortem gave clear evidence of marked changes throughout the whole shaft of one humerus, there being radiating striations perpendicular to the surface such as are found in many cases of bone sarcoma, in addition to a generalized destructive process and a pathological fracture. In several other bones, including the frontal, there was also some degree of destruction. A large mediastinal tumor was present. Reports of such bone metastases from thymoma are very rare.

DR. DOUB (closing): I am indebted to Dr. Pfahler for a very clear history of his case. This is a typical history of a number of cases which I have encountered in the literature of this subject.

In regard to Dr. Smith's case, the reason I believe it to be a thymoma is the fact that the patient had enlarged glands for two years and some difficulty in breathing. The lesion on the humerus was only incidentally found; the patient had no symptoms there which would lead one to believe they were due to a recent lesion. The fact that he found multiple bone lesions after that would indicate that they were metastatic rather than primary. The pulmonary osteo-arthropathy would also go with a long-standing chest tumor.

ROENTGEN DIAGNOSIS OF CANCER OF THE ESOPHAGUS[1]

By JOHN T. FARRELL, JR., M.D., PHILADELPHIA

THE hope of cure in malignancy lies in early recognition. Bloodgood (1) has compared the stage at which patients to-day present themselves for diagnosis of lumps in the breast with the stage at which they appeared some twenty-five years ago. In his clinic he finds that only 17 per cent of patients presenting themselves to-day for diagnosis of a lump have cancer, whereas, in the earlier period, 80 per cent had cancer, and less than 50 per cent were operable. Other observers have noted a similar increase in recent years in the incidence of benignity and operability of breast tumors (Gibbon, 2), (Klopp, 3). This change is due to increase in diagnostic acumen and to an increased popular knowledge of the course of cancer of the breast, leading patients to seek examination earlier.

This is not the case in cancer of the esophagus. Hickey (4) says that the status of the diagnosis and treatment of esophageal malignancy is an indictment of modern medicine. Jackson (5) believes that this is due in part to the physician and in part to the patient; both disregard the initial symptom, difficulty in swallowing, because of its triviality. This is unfortunate. According to Jackson (6), cancer of the esophagus is often of a mild degree of malignancy and frequently could be cured by surgery if applied early. It is essential, then, that every patient complaining of the slightest difficulty in swallowing be studied thoroughly before being dismissed as free of esophageal disease.

Roentgenology offers the most universally practicable method for the diagnosis of disease of the esophagus. While it falls short of direct esophagoscopy in accuracy, it is much simpler and more readily available. It is infinitely superior to blind bougienage, a method always dangerous, usually uninformative, and never altogether conclusive.

Roentgenologic examination of the esophagus consists in observing it fluoroscopically while its lumen contains an opaque medium. This may be done while the patient is standing or lying down: for a thorough study it must be done in both positions.

The opaque material is ingested as fluid, semi-solid or solid. Barium or bismuth salts are administered as thin watery mixtures or as thick gruels; mixed with cracker crumbs, jam, or cocoa they may be given as semi-solids; in gelatin capsules or as gelatin-impregnated blocks, after the manner of Hickey (17), they may be swallowed as solids. According to Hickey the blocks produce less discomfort when stopped than do the rigid capsules, but it is our experience that the capsules produce very little if any discomfort and that the ease with which the capsule is filled is an advantage. William H. Stewart (7) has recommended the use of sausage skins filled with opaque material. All consistencies may be employed, with the patient standing, but when he is recumbent only fluid mixtures are practical.

Standing, the left oblique is the position of choice. With the right shoulder toward the screen and the left toward the tube the patient is at such an angle that the central ray enters the body at about the left midscapular line, passes between the heart and the spine, to emerge at the right axillary line.

The right oblique prone position is the most satisfactory for examination in the horizontal plane. This has been well described by Manges (8). With the screen

[1] From the X-Ray Department, Jefferson Hospital.
Read before the Radiological Society of North America at the Fifteenth Annual Meeting, at Toronto, Dec. 2–6, 1929.

above the patient and the tube beneath the table, the patient lies with his right cheek and shoulder on the table, the right arm and hand behind, and the left leg flexed and drawn up in such a way as to rotate the body on the extended right leg and hip. In this manner the left shoulder is lifted well off the table, and with the left arm flexed the left hand can steady the drinking tube. In this position the central ray enters the chest at about the right anterior axillary line, passes behind the heart and in front of the spine, to emerge at the left posterior axillary line. By having the patient draw the opaque fluid through a drinking tube the esophagus may be filled throughout its entire length, because the flow is uphill, the introitus being appreciably lower than the hiatus.

The normal esophagus is smooth and of an almost uniform width throughout, though it does show anatomical points of narrowing (1) at the introitus; (2) in the cervico-thoracic portion where it passes from the neck into the chest; (3) at the crossing of the left bronchus, a point close to the arch of the aorta, (4) and at the hiatus. At the level of the arch it is smoothly indented on its anterior surface, and it tapers at its termination at the hiatus

The roentgenologic appearance varies with the position of examination. When the patient is erect the opaque fluid passes readily to the stomach, pausing at the hiatus for only a second or two. A well-moistened capsule, 00 size, when swallowed in this position passes from the mouth to the stomach with only momentary delay at the points of anatomical narrowing Hickey (17) says that a normal patient should be able to swallow comfortably a gelatin bougie 14 mm in diameter

It may be said that the normal esophagus does not evidence peristalsis when examined in the erect posture with fluids, though momentary delay at the hiatus is often seen in those of nervous temperament. Gentle

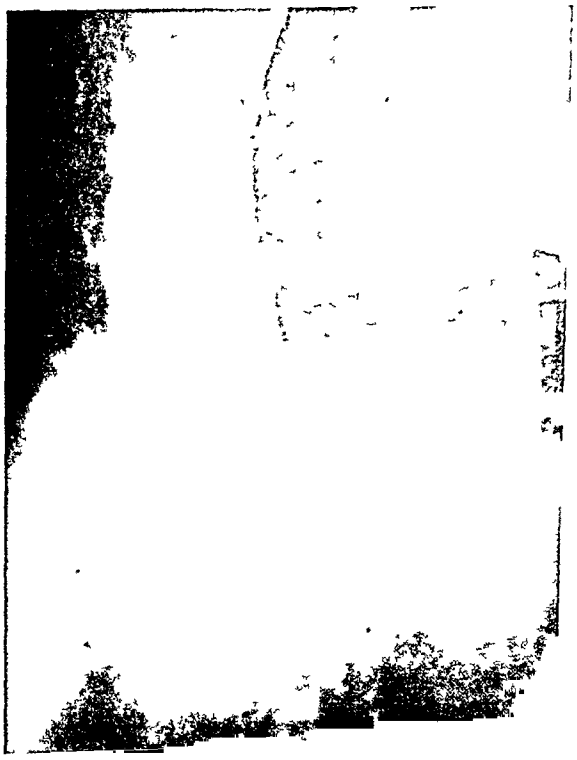


Fig 1 Punched-out filling defect at the hiatus (Patient is a male, aged 75) After esophagoscopy, Dr Louis H Clerf reported a large fungating mass a short distance above the hiatus On section, Dr Baxter L Crawford reported adenocarcinoma

peristalsis is seen when semi-solid boluses are swallowed With them, the waves mold the mass by pressure from above and force it toward the stomach, with a tapering point due to the resistance the mass meets in forcing the normally collapsed walls apart.

When examined in the prone position the esophagus is smooth, but the cervico-thoracic narrowing, the aortic indentation, and the hiatal tapering are more readily recognized because the effect of gravity is minimized In this position peristalsis begins as a gentle wave high in the thorax and passes to the hiatus; the opaque mixture is never divided by this wave normally. During the ingestive period the opaque mixture is expelled as an almost continuous stream, with occasional accelerated spurts. In nervous individuals, the spurts are more pronounced and the mixture runs up and down the structure—a regurgitatory proc-



Fig. 2. Annular filling defect. (Patient is a male, aged 48.) On esophagoscopy, Dr. Louis H. Clerf found an extensive lesion involving the upper esophagus. On section, Dr. Baxter L. Crawford reported a squamous-cell epithelioma.

Fig. 3. Infiltrative filling defect. (Patient is a male, aged 64.) On esophagoscopy, Dr. Louis H. Clerf found a large fungating mass immediately above the hiatus. On histologic examination, Dr. Baxter L. Crawford reported a squamous-cell epithelioma.

ess—until the last of it passes into the stomach about thirty seconds after its ingestion.

Air is swallowed in varying amounts by normal individuals in the erect posture. Practically no air is swallowed when the opaque mixture is taken in the prone position through a tube.

As in other hollow viscera, the filling defect is the sign of esophageal organic disease. In the 77 cases on which this study is based it occurred in 15 instances in the upper third, in 30 in the mid-portion, and in 32 in the lower third. In all but one instance the filling defect was irregular, the character and extent of the irregularity being in a large measure associated with the site. At the hiatus it was sometimes "punched out" of a bulbous tip (Fig. 1); in the mid-portion it might be annular, when due to circumferential growths (Fig. 2), or jagged when the neoplasm was infiltrative (Fig. 3). It may be impossible to determine the exact irregularity when the lesion is high in the esophagus, because overflow into the larynx, with subsequent coughing, may prevent swallowing of a sufficient amount of the opaque fluid to outline the growth. The filling defect is quite regular in some cases of infiltrative carcinoma at the hiatus; in these, the hiatus tapers but is rigid and blunt.

Two structural changes automatically follow esophageal obstruction from any cause: (1) narrowing at the point of obstruction; (2) dilatation proximal to it (Figs. 1 and 2). Narrowing occurred in all of the 77 cases at the site of the growth. It was central when the carcinoma was annular (Fig. 2), and excentric in the

fungoid infiltrative type (Fig. 3). In lesions at the hiatus narrowing may not be pronounced because of protrusion of the growth into the cardia. Narrowing in lesions in the upper third may be so marked that it is impossible to fill out the esophagus at a lower level.

Dilatation of the proximal portion is rarely the significant finding in cancer that it is in the other esophageal lesions. It occurred in all but 4 of our patients, in 61 it was very slight, in 12 it was definitely pronounced. Three of the four cases without dilatation occurred in the lower third, the fourth was an infiltrating polypoid cancer of the middle third. Location of the lesion bears no relation to the absence of dilatation, because, in the other 29 patients, with involvement of the lower third, there was appreciable widening. Increased peristalsis is unusual in these cases. The relatively slight dilatation and the lack of increased peristalsis is probably due to the usual short course of the disease. The duration before death is too brief to permit of the marked dilatation and increased peristalsis seen in benign obstructive lesions of long standing.

Metastasis and pulmonary infections sometimes complicate esophageal cancer. Enlargement of the mediastinal lymph nodes does not occur to any great extent in this disease. Typical metastatic nodules are sometimes seen in the lungs, but their occurrence is only occasional. In this tendency of the lesion to remain local and to metastasize late some hope of cure is seen, if the diagnosis can be made early. Metastases to other organs are sometimes found at autopsy, and in some instances enlargement of the liver or metastasis to the bones may be demonstrated roentgenographically.

Lower lobe pulmonary infection is a frequent complication of esophageal malignancy (Fig. 4). It occurs particularly when disease in the upper third produces marked narrowing; overflow into the respiratory passages brings about an aspiration infection. Roentgenographically there is a bilateral exudative increase in the lower lobe markings suggestive of bronchiectasis. The extent of the change depends upon the duration of the disease. Clinically, cough and expectoration accompany these pulmonary infections. Sometimes there is elevation of temperature.



Fig. 4. Lower lobe aspiration infection, with metastatic nodule complicating cancer of the upper third of the esophagus. (Patient is a male, aged 68.) Dr. Louis H. Clerf reported an extensive fungating lesion below the suprasternal notch. Dr. Baxter L. Crawford reported the tissue as squamous-cell epithelioma.

Fistulous communication between the esophagus and trachea (Fig. 5) or the esophagus and a bronchus may follow erosion of these structures by the newgrowth. In his study of esophageal roentgenography Pancoast (9) has an illustration of a similar case.

DIFFERENTIAL DIAGNOSIS

Among the organic conditions which must be differentiated from carcinoma of



Fig. 5. Esophagotracheal fistula. (Patient is a male, aged 41.) At esophagoscopy, Dr. Edmund L. Aucoin found almost complete obstruction by an infiltrating fungating mass 26 cm. from the incisors, with dilatation of the proximal portion of the esophagus. Dr. Baxter L. Crawford reported the tissue as squamous-cell epithelioma.

the esophagus are cicatricial stenosis, stenosis from external pressure, esophageal varix, diverticulum, esophagitis, foreign body, and esophageal extension of gastric malignancy.

Phrenospasm, central nerve lesions such as bulbar palsy, and hysteria are the functional conditions with which esophageal malignancy may be confused.

Cicatricial Stenosis.—The history is important in the differentiation of this condition, seen more commonly in children than in adults. Unwitting swallowing of improperly labeled commercial lye is the most prolific source of esophageal burns (Jackson. 10), (Clerf, 11). When it is known that an acid or caustic alkali has been swallowed the diagnosis is readily made. Narrowing, the most striking roentgen characteristic, may extend throughout the length of the esophagus, or for only a few millimeters. The narrowed walls are usually smooth, and sometimes the scar is tapering in outline (Fig. 6). The degree of proximal dilatation depends upon the site of the cicatrix, its length, width, and duration. When high, there is very often no dilatation; this is also true when the entire length of the organ is involved. A localized scar in the middle or near the hiatus, with marked stenosis, may double the breadth of the proximal portion and lead to vigorous peristalsis. While dilatation and peristalsis are more marked in benign cicatricial stenosis than in cancer they never attain the proportions that they do in phrenospasm.

Stenosis from External Pressure.—Pressure from an aneurysm of the aorta, from a mediastinal newgrowth, or enlarged mediastinal lymph nodes may sometimes be confused with carcinoma of the esophagus. Aneurysm is practically always recognizable roentgenologically, and the narrowing it produces in the esophagus corresponds to its site, is smooth, and usually curved or crescentic in outline. This is also true of generalized dilatation of the aorta without aneurysm (Fig. 13).

When large enough to produce pressure, mediastinal neoplasms are usually readily recognized either fluoroscopically or on films of the chest. Dysphagia is not a common symptom of these conditions though it does sometimes occur. Deformity of the esophagus produced by mediastinal tumors is found at the site of the tumor and is smooth in contour.

The deformity due to metastatic enlargement of the mediastinal lymph nodes is similar to that of aneurysm and primary mediastinal neoplasm. Sometimes the esophagus is caught and occluded in a mass of metastatic nodes (Fig. 7). In these cases history of a remote primary growth is important.

Esophageal Varix. — Enlargement and rupture of the veins of the esophagus may lead to hematemesis (Jackson, Tucker, Clerf, Lukens, and Moore, 12). In some cases filling defects similar to cancer are observed (Fig. 8). While clinical recognition of hepatic cirrhosis may hint at the origin of the changes in the esophageal outline, direct esophagoscopy is the only way by which the condition may be differentiated from intrinsic malignancy.

Diverticulum.—In most instances a single diverticulum occurs in the upper third of the esophagus and only occasionally in the middle or lower third (Fig. 13). Sometimes the sacculation may be double; in rare instances it may be multiple, as in the case reported by Roldan (13). While difficulty in swallowing may suggest cancer, roentgen examination will readily demonstrate the characteristic pouch. Sometimes after surgical removal the dimple of the stump may retain the opaque mixture, or puckering of the wall at the site of the extirpation may suggest a filling defect (Fig. 9).

Esophagitis.—Ulceration and granulation tissue of benign origin produce constant filling defects similar to those seen in ulceration secondary to malignancy. Clinical symptoms of dysphagia, pain in the chest, and loss of weight accompany the condition. Differentiation can be made only by direct esophagoscopy, with the removal of a piece of tissue for histologic study.

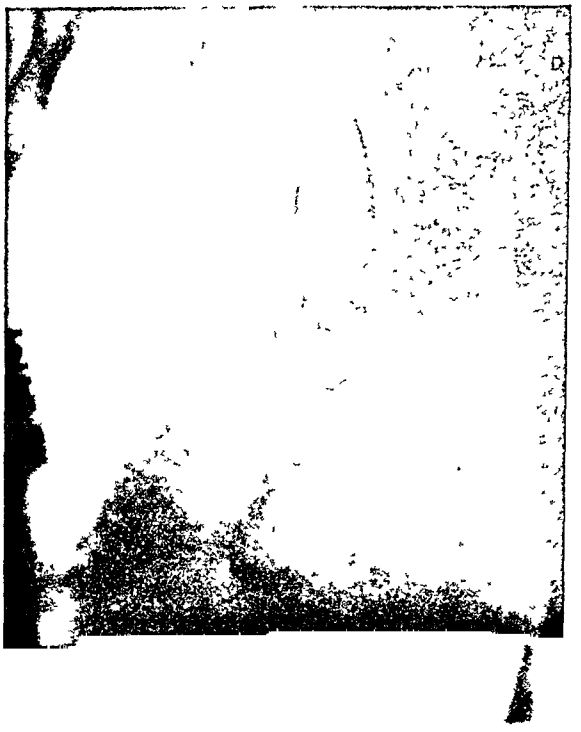


Fig. 6. Esophageal stenosis due to the swallowing of a caustic. The patient, a male, aged 40, had swallowed a caustic, probably lye, twenty-one years before the present examination. At esophagoscopy, Dr. Louis H. Clerf found almost complete stenosis just above the hiatus. The walls were smooth.

Foreign Body in the Esophagus.—No difficulty is encountered when the foreign body is opaque, but with non-opaque substances the conditions may not be clear. In adults, the history is important and usually points to a foreign body. In the insane, dysphagia, with regurgitation, might lead to the clinical diagnosis of neoplasm. Clerf (14) reports the case of an insane patient in whom, because of suicidal tendencies, refusal to take food was ignored until it was observed that he was not swallowing his saliva. Ordinary roentgenograms of the neck and chest failed to reveal a foreign body, but Manges demonstrated complete obstruction to the passage of the opaque mixture



Fig. 7. Esophageal stenosis due to enlarged metastatic mediastinal lymph nodes. Dr. Frederick J. Kalteyer's patient, a female aged 54, having scirrhous carcinoma of the breast, with metastasis to the lungs and pleura. Marked relief after deep X-ray therapy given by Dr. Willis F. Manges. Dysphagia developed later, and Dr. Manges reported esophageal obstruction. On esophagoscopy, Dr. Chevalier Jackson reported pale, edematous, swollen mucosa above a tight stenosis but no evidence of ulceration.



Fig. 8. Esophageal varix. (Dr. Frederick J. Kalteyer's patient, a male, aged 58.) On esophagoscopy, Dr. Louis H. Clerf found a purplish mucosa, with definitely enlarged veins at the hiatus; no evidence of infiltration, ulceration, or external compression.

and at esophagoscopy Clerf removed a large pecan.

As Manges (15) points out, a bolus of food or other material lodged in the upper end of a stricture will produce a different type of filling defect than cancer: the opaque mixture will spread over the foreign body so that the lower border of the column is concave. In some instances a bolus may be caught in a normal esophagus and produce a similar defect in the stream (Fig. 10).

Difficult swallowing of sudden onset due to the occlusion of the esophagus by food caught at the site of malignant disease may be the first symptom of carcinoma. For this reason the esophagus should be re-examined after the esophagoscopic removal of any foreign body.

Cancer of the Cardiac Portion of the Stomach.—Gastric cancer may lead to spasm at the hiatus, or, by extending into the esophagus, produce a filling defect. In cases of phrenospasm in those past middle age the possibility of gastric cancer as the causative factor must be borne in mind (Fig. 11).

Hickey (16) recently emphasized the difficulty of diagnosing cancer of the cardia and suggested the recumbent left lateral position as being valuable in the study of patients in whom this condition is suspected.

He enumerated the roentgen signs of gastric cancer at the cardia as:

"1. Irregularity in the spurting of the barium from the esophagus into the stomach.

"2. Irregularity in the outline of the cardia in the Trendelenburg or left lateral position.

"3. Constancy of deformity in serial films.

"4. Marked gastric hypermotility."

Phrenospasm or Prevcntriculosis (so-called cardiospasm).—This condition is characterized clinically by many of the features of esophageal malignancy, notably dysphagia and regurgitation Sometimes there is thoracic pain and loss of weight. Phrenospasm is distinguished by its chronic course, adults often dating the symptoms back to childhood. These patients usually come under observation at an earlier age than do those suffering from malignancy.

The roentgen appearance is striking in a pronounced case. Spasm at the lower end of the esophagus delays the opaque fluid in its passage to the stomach, the length of the delay being from a few seconds in the mild cases to hours or even days in the severe. Unlike cancer there is no filling defect, the esophagus being smooth throughout and the lower end tapering to a point. The esophagus dilates in some instances to four or five times its normal width, because of the great length of time before symptoms reach a stage requiring treatment. Peristalsis is usually vigorous. Immediately after the ingestion of the mixture deep waves may pass from the suprasternal notch to the hiatus in an attempt to force the material through. Later the waves diminish in intensity, and finally, with exhaustion of the musculature, cease altogether. The esophagus may be so filled with liquid food remnants at the time of the first examination that a considerable length of time may be required for the opaque mixture to seep through the material to the hiatus.

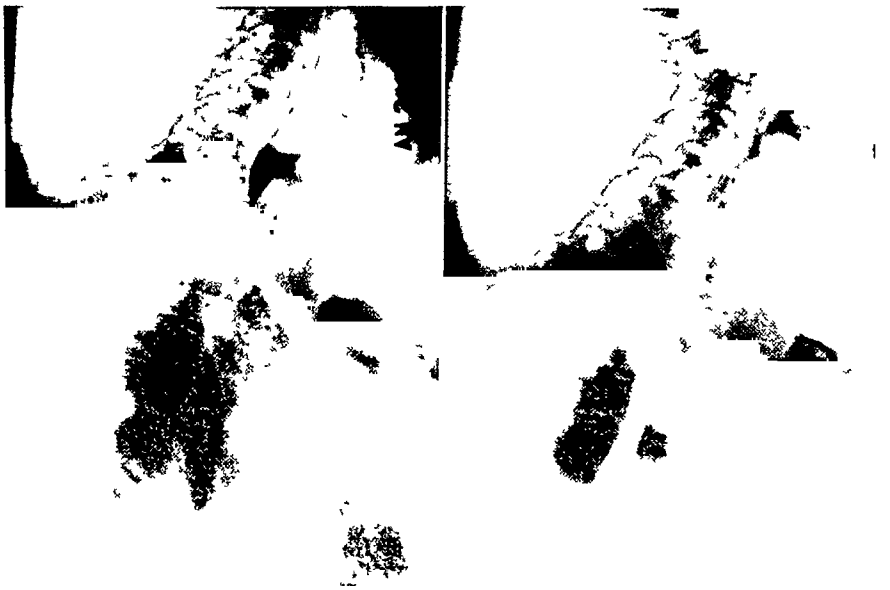


Fig. 9. Diverticulum, before and after removal. (Patient is a male, aged 58.) Surgical extirpation through the neck by Dr. Thomas A Shallow and Dr. Louis H. Clerf. Post-operative roentgen study done during convalescence, before complete recovery

Lesions of the Nervous System.—Bulbar palsy, occurring as it does at the same age



Fig. 10. Foreign body (bolus of food). (Patient is a male, aged 45) At esophagoscopy, Dr. Louis H. Clerf removed a large bolus of meat. Esophagoscopically and roentgenographically the esophagus was normal after removal of foreign body.



Fig. 11. Phrenospasm secondary to gastric malignancy. (Patient is a female, aged 62.) At esophagoscopy, Dr. Louis H. Clerf found the entire thoracic esophagus dilated but the mucosa normal except for esophagitis at the hiatus. The hiatus was smooth and showed no evidence of ulceration. Under the fluoroscope and on the film the esophagus was seen to be smooth throughout its course. A filling defect on the lesser curvature can be seen.

period as malignancy, is the most important of these. In this condition coughing and choking caused by the passage of the opaque material into the larynx may make it impossible to fill the esophagus. The esophageal stream may be so thin that one cannot rule out a massive lesion high in the esophagus. The history of regurgitation through the nose, drooling, and speech difficulties, together with the absence of demonstrable obstructive lesion, may serve to differentiate the two conditions.

In localized conditions of the nerves controlling the muscles of deglutition like difficulties may occur (Figs. 12 and 13). Esophagoscopy should be done in cases of these types in which the roentgen diagnosis is not conclusive.

Pulmonary infection of the aspiration type, similar to that seen with cancer high in the esophagus, is a common accompaniment of bulbar palsy.

Hysteria.—Patients suffering from globus hystericus and complaining of a lump in the throat due to spasm of the pharyngeal muscles are frequently referred for diagnosis. The absence of organic lesions can be readily demonstrated. Dysphagia as an accompaniment of other hysterical states is rare. When it does occur it is usually seen in young females, in contrast to esophageal cancer—a disease of males in the later age periods. When the patient can be induced to swallow, the normal condition of the esophagus becomes at once apparent.

CONCLUSIONS

1. The present status of the diagnosis and treatment of cancer of the esophagus is

unsatisfactory because of the impossibility of cure at the late stage at which these patients come under observation.

2. Even the slightest difficulty in swallowing must be investigated thoroughly before it is dismissed as inconsequential.

3. Roentgenology offers the most universally practical method for the diagnosis of diseases of the esophagus.

4. In this series of 77 cases of cancer of the esophagus the disease occurred 15 times in the upper third, 30 times in the middle, and 32 times in the lower.

5. A filling defect was observed in all patients; in but one instance was it smooth; in the other 76 it was irregular.

6. Narrowing at the site of the growth was a constant finding.

7. Slight dilatation of the proximal portion was present in 73 instances; in 4 it was absent.

8. No relationship existed between the site of the growth and the absence of dilatation.

9. Increased peristalsis is not a prominent feature of cancer of the esophagus.

10. Metastases and lower lobe pulmonary infections occur as occasional complications. Erosion of the trachea or a bronchus, with the creation of a fistulous tract, is rare.

11. The following organic lesions must be differentiated from cancer of the esophagus: cicatricial stenosis, stenosis from external pressure, esophageal varix, diverticulum, benign esophagitis, foreign body, and extension of gastric malignancy.

12. Phrenospasm, or so-called cardiospasm, central nervous system lesions such as bulbar palsy, localized lesions of the nerves controlling the muscles of swallowing, globus hystericus, and hysteria are the functional conditions which must be differentiated.

13. In all conditions in which a positive diagnosis as to the presence or absence of organic disease of the esophagus cannot be made by roentgen study, esophagoscopy should be employed.

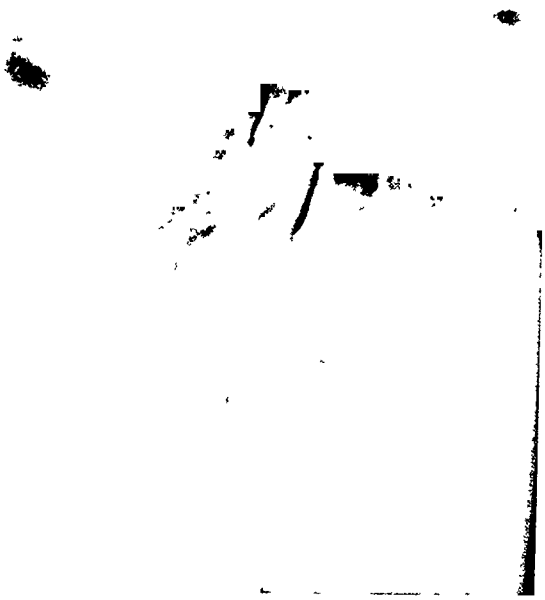


Fig. 12. Anterior laryngeal and tracheal walls outlined by overflow. (Dr. Robert M. Lukens' patient, a female aged 72; see also Figure 13.) Overflow of the mixture into the larynx prevented proper filling of the esophagus and a diagnosis of probable newgrowth in the esophagus was made. At esophagoscopy, Dr. Lukens found the esophagus normal throughout.

I am indebted to Dr. Chevalier Jackson and the Staff of the Bronchoscopic Clinic, by whom most of the patients on which this study is based were referred, for permission to use the clinical data.

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Fig. 13. Smooth indentation at the level of the arch, with a small diverticulum in the middle third, in a patient with dysphagia due to disturbance of the deglutitory muscles. (Same case as shown in Figure 12.) On the left a feeding tube passes the entire length of the esophagus; on the right the filled esophagus is shown after recovery.

DISCUSSION

DR. SYDNEY J. HAWLEY (Danville, Pa.): There are a few points which are so easily overlooked in the daily routine of our work that they should be emphasized. In the first place, we should diffuse information among the public and profession about the necessity for early examination. The examination of the esophagus is not an easy one to make, and when the patient does come for such an examination it behooves us to be very care-

ful and to examine from all directions. We must be wary about the interpretation of smoothness of outline. As Dr. Farrell mentioned in one case of carcinoma of the esophagus, the outline was smooth. On account of this fact and also because certain benign lesions are indistinguishable from early carcinomatous lesions, we must depend on the esophagoscope for the final word.

Another point which is of great importance, yet frequently omitted, is the examination of the esophagus after the removal of the foreign body. If this is carried out, you may pick up a very early lesion.

Another point of importance which Dr. Farrell brought out is that of persistent delay at the lower end of the esophagus, which may be an indication of the disease in the cardiac end of the stomach. We, as roentgenologists, should never make a diagnosis of globus hystericus: that should be left for the esophagoscope. If that reveals no signs, then the esophagoscopist may say that the difficulty in swallowing is hysterical.

DR. MAURICE FELDMAN (Baltimore): In a report of 128 cases of carcinoma of the stomach in our clinic, we have met with a small number of early cases of carcinoma of the esophagus. The essayist and the previous discussants have mentioned the fact that particular attention must be paid to the esophagus when there are esophageal symptoms. Now why do we have to wait until esophageal symptoms develop? Every X-ray examination of the gastro-intestinal tract requires a thorough esophageal examination. It has been my experience that if the esophagus is examined more thoroughly in the routine examination, regardless of the symptoms, we may find the earlier signs more readily.

Most of the slides shown on the screen were those of obstruction. Carcinoma with obstruction offers very little difficulty in the diagnosis. When you get obstruction, with an irregular defect, it offers little difficulty in diagnosis, but the early cases do not show signs of an obstruction. I have a slide here to show of a patient who had practically no symptoms relating to the esophagus —the only symptom this patient had was heartburn. We made an esophagoscopic examination and found a small epithelioma about the size of a pea. Peptic ulcers were also reported, following both experimental and human tests. We have never found any difficulty in differentiating peptic ulcers from carcinoma. In one case because the patient had obstructive signs, we made a diagnosis of an esophageal lesion and the esophagoscopic examination revealed a carcinoma.

DR. A. L. LOCKWOOD (Toronto, Canada): It is with considerable temerity that I, as a mere surgeon, appear before such an austere Society as yours, especially to discuss such a subject; because, as Will Rogers would say, from what I read in the papers, it would appear that cancer is to be removed entirely from the realm of surgery to that of radiology. There are certain types of cancer which I would be very glad to turn over to the radiologist. I would be pleased to let him have cancer of the cervix, cancer of the liver, and cancer of the esophagus.

I would not try to enlarge upon Dr. Farrell's most excellent résumé of this subject, or upon the remarks of Dr. Chevalier Jackson. If there is anyone in this world who knows anything about the subject, it should be Dr. Jackson. However, I think we should constantly keep in mind the necessity of the most meticulous and careful examination of every patient who complains of any difficulty in swallowing. No matter how slight the difficulty may seem, we cannot do too much to determine the cause.

About eight or ten years ago I had an opportunity of seeing a patient, with a very much older consultant whom you all know, a man of vast experience. As we approached the consulting-room a younger doc-

tor said to the consultant, "This is a very interesting patient, and we think he has an hysterical aphasia." The patient said that practically all his life he had had something tugging in this side of his neck. About sixteen or eighteen years ago, while drinking in a creek, something came into his throat and he choked, and it came out of his mouth and he clutched it in his fingers, but lost it. About eight or ten years later the same thing happened again. He had seen this little red thing coming out of his mouth, and he had caught it in his fingers, but it got out of his fingers again. The old consultant, who was experienced, turned the man upside down on the table and said to him, "Cough." To my surprise something red came out of his mouth and I grasped it, but lost it again. The esophagoscopic examination revealed a large tumor, fixed to the esophagus opposite the cricoid cartilage. It was removed surgically and was found to measure 11 centimeters in length and about 2 centimeters in diameter—a hemangioma.

I have just seen a woman who had been diagnosed as having hysterical aphasia. Having this other case always in mind, we examined her with an esophagoscope. A short distance down the esophagus we came to a blind pocket. If I had had the least idea that Dr. Jackson was going to be here to-day, I would have had him see this woman. I could not get even a thread down her throat. She gives a history of some sixteen years' duration and says that "when a sister was burned she got this trouble." She cannot get any solids down, and fluids only very slowly. As I said, I could not get a linen thread down her throat. We have let her go home, but will have her back again and try again to pass the esophagoscope. The esophagus tends to contract gradually to a funnel-like constriction, but we could not find an opening.

What are we going to do to help patients with cancer of the esophagus? I am convinced that the majority of them have to be left for radium or deep X-ray therapy. I have seen only one case in which I hoped to do something surgically. After experimental work on dogs, I now believe that if I had used an epithelized tube-graft the patient would be alive to-day.

As Dr. Jackson points out, the cases discovered almost by accident are the only ones which we see early enough to be able to do anything with surgically. If we are going to get anywhere as surgeons with cancer—apparently we are not, from the papers—we have to learn when to hold our hand; and that is particularly true in cancer of the esophagus. If the surgeon is to be allowed to deal at all with the esophagus, he must know when to stop. The last three cases I stopped at once after exposing the lesion, and after realizing that further surgery was not practicable. The surgeon must make it clear to the patient that he is not sure how much he can do, but that exploration will not do any harm. If the growth is too extensive, or if the surgeon does not think he is going to have a fair chance of getting a satisfactory union, preferably by an epithelized graft, he should close the incision without attempting anything further.

I think an extremely small percentage of cases would be surgical, but it would as yet seem as if they must be discovered almost by accident to be early enough to be dealt with surgically at all. If we cannot do anything surgically, what else can we do? Apart from X-ray or radium therapy, I think all we can do is by dilatation. I have seen quite a number of patients with cancer of the esophagus during the last fifteen years, yet have seen but one esophagus through which I could not get a linen thread. Undoubtedly there are such cases, and with some of them we have had to persist for some time; but if we have been able to get a linen thread through, with a metal dilator, we have been able to dilate the esophagus and get the patient back to solid or semi-solid food, or at least to fluids. If you can get even fluids

through it will relieve the situation, as these patients are intensely dehydrated. We recently had a patient, now dead, whom we dilated. He did well, so much so that he thought he was going to be cured; but he dropped dead suddenly about five months later. The letter which his wife wrote to us tells how greatly he was relieved of his intense thirst by being able to take fluids. We now have a man who has experienced this relief for about eleven months, and he came in the other day with a banana to show us how he could get even a banana down. He is now losing weight, however.

While I am about ready to turn over all cancers of the esophagus for X-ray or radium therapy, yet there may be an occasional case which will be diagnosed early enough to be available for surgery. In addition, I have not observed any benefit whatever from the use of radium or X-ray therapy.

DR. CHEVALIER JACKSON (Philadelphia): This presentation by Dr. Farrell is intensely interesting to me, and all the more so because I have seen a number of the patients in consultation with Dr. Farrell.

One of the most important points, I think, is that all of the diagnoses of cancer of the esophagus are late; and the reason why they are late is that the patients are not seen by either the roentgenologist or the esophagoscopist until there is difficulty in swallowing solids. We rarely see these patients in the early stages of the disease. The early stages of cancer of the esophagus are associated with such vague symptoms, and the sensations are so ill-localized by the patient, that the average practitioner makes a diagnosis of hysteria. All patients coming in with cancer of the esophagus report two forms of diagnosis: (1) spasm, and (2) hysteria, sometimes nervousness. The history of the case is absolutely worthless for diagnosis. Some patients with a history of intermittent difficulty in swallowing have had this difficulty for twenty years; whether old or recent, intermittent dysphagia in these cases is due not to spasm but to the lodgment of food which has later softened and passed on. On the other hand, many patients with cancer stoutly maintain that they never had difficulty in swallowing before to-day, yesterday, or last week. The history of the case, therefore, is worthless, because we would infer that a cancer could not be present for twenty years, nor could it develop in a day.

There are only two means of diagnosis of any esophageal disease that are worth a moment's consideration; these are roentgen-ray examination and esophagoscopy; both should be used. There are only two diseases of which the ray fails to give evidence: one is esophagitis and the other is peptic ulcer of the esophagus. In general, it may be said that roentgen-ray diagnosis of cancer of the esophagus is 98 per cent correct.

DR. JOHN T. FARRELL, JR. (closing): The points have been very well taken. It is important for us to remember the possibility of esophageal disease producing symptoms commonly referred to lower areas in the gastro-intestinal tract.

OSTEOGENIC TUMOR: GROWTH INJURY OF BONE AND MUSCULAR ATROPHY FOLLOWING THERAPEUTIC IRRADIATION[1]

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THE specific sensitiveness of different varieties of cells to radiation is rapidly becoming recognized as the evidence furnished by experimentation on animals is becoming known and as extensive clinical experience is daily confirming the experimental data. The variation in the relative vulnerability of different kinds of cells to roentgen and radium rays has been shown to provide a valuable means of identifying the cells in normal and pathologic tissues and even of distinguishing certain kinds of tumor. Indeed, such identification of cells by their reaction to irradiation promises to add much to our knowledge of the histogenesis, physiology, and pathology of many tissues, and especially of neoplasms. The exceptional radiosensitiveness of the small round cells which characterize the lymphoid structures and which constitute an important component of the blood, and of the seminal and follicular epithelium of the testis and ovary, respectively, is now so well known as to have become established. This is not yet true, however, concerning bone, which still is generally thought to possess a marked degree of resistance to irradiation. Many radiologists seem to regard bone as absolutely impervious to the influence of irradiation, but such an attitude does not rest on knowledge of the facts relating to the specific sensitiveness of bone. It is true that, in the adult body, the relative resistance of bone to irradiation is almost as great as that of the brain and nerve tissue, but an excessive single or total dose of roentgen or radium rays may cause injury to bone. But while adult bone can tolerate relatively large doses of radiation, the rapidly growing osseous structures of young animals are influenced deleteriously, even by small doses.

In comparison with many other tissues, experimental investigation of the radiosensitiveness of bone has been limited. This is undoubtedly due to the circumstance that the exposures incidental to radiography are insufficient to induce any alterations in such a dense and resistant tissue as bone. Indeed, even the much longer exposures to rays of shorter wave length currently employed in radiotherapy rarely cause recognizable abnormalities in bones subjected to irradiation. At least, this is the only conclusion which can be drawn from the paucity of reports of such injury, even if it is granted that such injury often may not be recognized. A brief review of the experimental and clinical evidence, therefore, may be worth while.

EXPERIMENTS ON ANIMALS

Perthes (1903) exposed the right wing only of three chicks, one day old, to 12 Holzknecht units of roentgen rays, for forty-five minutes, at a distance of 10 cm. When one of the animals was killed twelve days later, the growth of the irradiated wing was found to have been greatly retarded. Two other experiments having given similar results, Perthes deduced that roentgen rays can inhibit the division of cells, a conclusion which has since been amply substantiated.

Récamier and Tribondeau (1905) found, after exposing one side of the face of a kitten three days old to roentgen rays for sixty minutes, that the corresponding side of the skull as well as the eye failed to

[1]Read before the Radiological Society of North America at the Fifteenth Annual Meeting, at Toronto, Dec. 2–6, 1929.

develop normally and gave an asymmetric aspect to the head; even the teeth on this side were shorter than those on the unirradiated side. Récamier (1905) exposed the right side of the head of a kitten four days old to about 3 Holzknecht units of roentgen rays of medium wave length (No. 8 Benoist) for periods of ten minutes six times in sixteen days, at the rate of three times a week. The remainder of the body was shielded from the rays by a sheet of lead. Radiodermatitis, in the form of inflammation of the labial mucosa, appeared after the third exposure, and the reaction of the skin increased during the ensuing month. The visual acuity of the right eye diminished, and the snout gradually deviated toward the right side. When, one month after the last exposure, the animal was killed, at the age of seven weeks, the right side of the skull was found underdeveloped and abnormally thin, giving the skull an asymmetric appearance. In all probability such asymmetry would have been still greater if the interval between irradiation and death had been longer. Even the teeth on the irradiated side were smaller and shorter than on the unexposed side of the face. Récamier (1906), having obtained the same results in two other kittens irradiated in the same manner, irradiated the right leg of two young chickens and again found that, while the exposed bones grew in a normal manner, such growth was distinctly retarded; the exposed bones were shorter and more slender. An attempt was made, also, to test the action of roentgen rays on mature bone by irradiating one posterior extremity of an adult rabbit. When the animal was killed one month later, a perceptible difference between the exposed and the unexposed limb could not be found. Récamier attributed the apparent failure of the rays to influence adult bone to the short interval which had elapsed since the limb had been subjected to the rays. In young chickens and frogs, he also found that the only effect of irradiation on articular cartilages was retardation in development proportional to the influence on the bones. Perceptible histologic alterations could not be found. Récamier justly concluded that irradiation, under the conditions employed, retarded the development of the articular epiphyses of bone, but did not cause any apparent microscopic changes.

Försterling (1906) also investigated the action of roentgen rays on growth by exposing to the rays thirty-four rabbits, five dogs, and two goats. In twelve young rabbits the entire body was irradiated; four died or disappeared soon after exposure. Seven of the eight remaining animals, which had been exposed once to rather soft rays for from five to twenty-nine minutes, showed general, and sometimes considerable, retardation of growth, but their health was not otherwise disturbed. All the animals died sooner or later, and death was always preceded by rapid emaciation. In two other young rabbits only half of the body was irradiated; in both animals the exposed side exhibited marked retardation of growth, and this affected the external parts of the body as well as the internal organs. The dose of rays was less than that required to cause the skin to react. In nine other animals (eight rabbits and one dog between one and a half and eleven days old) the head and one or both forelegs were irradiated for from ten to twenty minutes. Definite retardation in the growth of the exposed bones resulted, and this was accompanied by peculiar disturbances of the nervous system. In seven young rabbits and four dogs, the posterior portion of the body, or only one hind leg, was irradiated. Distinct weakness of the posterior extremity developed in most of the animals. When only one posterior extremity had been exposed to the rays the difference in growth was always striking. In two young goats only the calcaneal region of one posterior extremity was irradiated for twenty min-

utes one and four days, respectively, after birth. Six weeks later a valgus position of the exposed ankle joint developed in both animals, while the unexposed ankle remained normal. Exposure of individual extremities did not influence the general growth, but a general effect on growth almost always followed exposure of the head or of more than a certain percentage of the body. The disturbance in growth was the greater the younger the animal or the larger the dose of roentgen rays.

Krukenberg (1909) exposed to roentgen rays a well-developed, pregnant dog more than one year old; in due time three well-developed pups, two living and one dead, were born. Two hours after birth the posterior portion of one and the anterior portion of the other living pup were irradiated for fifteen minutes. Both animals appeared to develop normally for two weeks, when the hair over the exposed parts of the body began to fall. Although the pup whose posterior portion had been irradiated continued to develop normally, the other soon became unable to stand and tended to fall backward. The dog fed itself with difficulty, became irritable, and only artificial feeding prevented its death. These nervous manifestations gradually subsided, but as time went on the growth of the irradiated anterior portion of the body was greatly retarded and the visual acuity was deficient from optic atrophy. The head, eyes, shoulders, and anterior extremities were abnormally small. The development of the other dog, the posterior portion of which had been irradiated, also was retarded. The posterior half of the body was smaller and the posterior extremities shorter than normal, and this gave the dog the appearance of a hyena. Krukenberg was uncertain whether the nervous disturbances were direct results of irradiation or whether they were secondary to the retardation in growth of the bones.

Cluzet (1910) fractured the leg bones of three rabbits and six dogs under anesthesia, applied a fenestrated plaster cast, and exposed the fragments to roentgen rays filtered through 1 mm. of aluminium. At first two bones in each animal were fractured and one bone was irradiated, the other being left unexposed to serve as a control. The animals died, however. Later only one bone in each animal was broken, and a corresponding bone in another animal was broken but not irradiated, to serve as a control. In the unexposed animals, callus around the fracture appeared between the eleventh and fifteenth days, whereas in the irradiated animals callus did not appear until the eighteenth day, and in two dogs until the twenty-first and thirty-fourth days, respectively. In spite of the apparent absence of callus, the irradiated fractures united partly or completely. In another dog, irradiated before fracture, callus did not become perceptible until the one hundred and seventh day, and this only on the side away from the roentgen tube. This was taken to indicate that the rays act on the bone cells and not directly on the callus. The fact that frequent roentgenography of bones in the control animals did not delay the formation of callus was held to mean that large doses of radiation are necessary to retard the deposition of callus. Iselin and Dieterle (1910-1911) found that total irradiation of the growing body inhibits growth, but that a single exposure may stimulate growth. In young dogs the injury caused by local irradiation was the greater the younger the animal and the larger the dose of rays; larger animals were affected but little. They also observed that irradiation of a portion of the body caused general disturbances. They apparently were unable to determine whether or not the retardation of growth induced by irradiation was the result of injury to the cartilages. In discussing this communication of Iselin and Dieterle, Bloch stated that he never had found any disturbance of growth in children less than

two years old who had been irradiated for microsporia.

Cluzet and Dubreuil (1913) pursued their investigation further by fracturing and irradiating the leg bones of eight dogs, and obtained identical results. They found that, from twenty to thirty days after irradiation, the formation of callus recovered its normal rate of growth. Iselin (1913) exposed to roentgen rays the joints of mice and rats four days old, two dogs five and nine weeks old, respectively, and one calf two months old, and roentgenograms of the irradiated joints were made at frequent intervals. The growth of the exposed bones was always retarded. After small doses, Iselin noted an acceleration of growth of distant, unirradiated portions of the body, while after large doses the growth of the entire body was inhibited.

Brunner and Schwarz (1918), having exposed the head of four dogs, four days old, to small, but unspecified, doses of roentgen rays, found, after a latent period of from ten to fourteen days, increasing retardation of growth, muscular tremor, epileptiform convulsions, and at necropsy increased cerebral pressure, swelling of the brain, and in one dog hemorrhage in the fourth ventricle. Brunner and Schwarz did not describe the condition of the cranial bones, but the character and sequence of the clinical disturbances suggest that they were the results of increased intracranial pressure and that this may have been due to impaired development of the cranium. Brunner (1920) exposed only the heads of four kittens to 40 Holzknecht units of roentgen rays generated at a voltage corresponding to a spark gap of 28 cm., filtered through 3 mm. of aluminium, at a focal skin distance of 22 cm. Two of these kittens were killed by the mother, but when the two remaining kittens were examined the sutures of the skull were still gaping, whereas the skull of a control kitten was completely ossified. Similar results were obtained in dogs.

Albee (1920), in an experimental attempt to produce pseudarthrosis by repeated massive doses of roentgen rays, was unsuccessful and stated that frequent, massive irradiation of fracture, with or without loss of bone, did not inhibit the formation of callus.

Phemister (1926), assuming that the bone lesions which characterize Legg-Perthes' disease, Köhler's disease, Osgood-Schlatter's disease, and osteochondritis dissecans probably result from interruption of the circulation of the affected region, undertook to produce experimentally a focal, aseptic necrosis of bone and cartilage by inserting radium needles into the knee or into the medullary canal of the femur of dogs. The radium was left in place for from eighteen to twenty-four hours, and the animals were killed at intervals varying between forty-five and four hundred days. Phemister found that aseptic bone, made to undergo necrosis by implantation of radium, reacts differently if mechanical function is or is not exerted; that when an entire segment of the femur or humerus of a dog is destroyed, and is subsequently used for weight-bearing, the dead bone does not form a sequestrum, but is slowly replaced by ingrowing new bone; that when nonunion of a fracture prevents the injured bone from being used, the necrotic bone forms a sequestrum which is slowly absorbed; that when the adjacent bone and soft parts are injured by radium the replacement of the necrotic bone by new bone is slower than when the necrosis results from circulatory disturbance or from the use of chemicals, and that secondary infection of bone killed by radium leads to formation of sequestra regardless of function.

Wynen (1929), influenced by Regaud's conception that, under irradiation, the calcium of bone causes emission of secondary rays, bored holes in thick bone and inserted into the holes the roots of horse beans; similar roots were inserted through muscle

and both the bone and muscle were exposed to the same dose of roentgen rays. At first the seedlings grew at the same rate, but when, after eight days, the lateral roots appeared, a striking difference was noted. Wynen found that bone absorbed more rays than muscle, and that the increased secondary radiation caused greater vascular injury in the bone because of its greater absorption. He also concluded that bone in rapidly growing organisms is more sensitive to radiation because of the relatively short life cycle of the bone cells. Wynen also investigated the production of bone necrosis by exposing the femur of guinea pigs and dogs to from 500 to 2,000 r-units at varying intervals. When the skin remained intact, he found it impossible to induce necrosis, but such necrosis always accompanied severe injury to the overlying soft parts. This led him to conclude that necrosis of bone cannot occur in the absence of mechanical injury or infection.

ANALYSIS OF EXPERIMENTAL EVIDENCE

The experiments of Perthes (1903), Récamier and Tribondeau (1905), Récamier (1905 and 1906), Försterling (1906), Krukenberg (1909), Iselin and Dieterle (1910-1911), Iselin (1913), Brunner and Schwarz (1918), and Brunner (1920) indubitably show that irradiation of young, rapidly growing animals causes more or less retardation in the growth of bones and other structures in the region exposed to the rays, and that the degree and duration of such inhibition is governed by the age of the animal and the dose of radiation. Iselin and Dieterle were the only ones to suggest that small doses may stimulate growth, but they did not submit any facts to support this assumption. The foregoing evidence also indicates that the retardation of growth is due to the direct action of the rays on the rapidly dividing cells of the epiphyses.

The investigations of Cluzet (1910) and of Cluzet and Dubreuil (1913) indicate that sufficient doses of roentgen rays do not prevent, but retard, the formation of callus around a fracture. Moreover, they showed that this effect resulted from direct influence of the rays on the bone cells, because the delay in callus formation occurred when the bone was irradiated before as well as after fracture. The fact that Albee (1920) was unable to observe such effect on the deposition of callus probably means that, in his experiments, the fractured bones did not receive a dose of radiation sufficient to inhibit the metabolic activity of the bone cells.

The experiments of Phemister (1926) and Wynen (1929) are extremely interesting and significant, because they furnish experimental proof of the soundness of the clinical and pathologic observations and of the validity of the deductions of Regaud (1922), Nageotte (1922), and Ewing (1926). The studies of Phemister with radium indicate the fundamental influence of mechanical function and infection on the reaction of bone to irradiation. In the absence of infection, bone devitalized by exposure to radium, but used for weight-bearing, does not detach itself from adjacent living tissues as a sequestrum, but is slowly replaced by ingrowing new bone. When, on the contrary, mechanical function is prevented by fracture, the devitalized bone separates as a sequestrum which is slowly absorbed. Impairment of the circulation of the soft parts overlying the necrotic bone delays its replacement by new bone. Secondary infection of bone killed by irradiation leads to sequestrum formation regardless of function.

CLINICAL CONSIDERATIONS

Regaud (1922) observed that large doses of radiation to an ulcerated epithelioma which has invaded the bone produces

peculiar necrosis of the bone, with complex lesions. He described two cases: one with an epithelioma of the skin and extension to the superior maxillary bone; the other with an epithelioma of the buccal mucosa and extension to the inferior maxilla. In both, the neoplasm improved considerably after repeated roentgen irradiation, but later infection developed, and this was followed by extensive necrosis of the bone, but the dead bone did not separate as a sequestrum. Such necrosis, in the many cases he had seen, always occurred in the bones of the head, secondary infection was always present, and the affected bone did not tend to separate from the adjacent living tissue. There was extremely slow, if any, tendency to formation of sequestra. Pursuing the subject further, Regaud (1922) reported that, in three cases with carcinoma of the tongue but without malignant invasion of the bone, in which radium had been applied to the floor of the mouth, against the mandible, ulceration and necrosis of the mucosa and bone occurred. He expressed the opinion, based on clinical observation, that ulceration of the mucosa inevitably leads to secondary infection, to which necrosis of the bone is due. He thought that the calcium of the irradiated bone emits secondary rays, which are easily absorbed and are very caustic. Irradiation was held to devitalize the bone and to render it a ready prey to infection, but the condition of the bone remained latent until infection caused active necrosis. The perspicacity of this observation was made obvious by Nageotte (1922), who examined Regaud's specimens. She found that, besides the death of cells, necrosis of a connective tissue involves an infectious or toxic element which provokes phagocytosis of the connective tissue fibers, the leukocytes being attracted by the infection. When infection is absent, the tissue may be destroyed without sequestration or without giving any external sign. She added that, in Regaud's cases, the bone had probably been killed by irradiation and the late necrosis was due to secondary infection.

Stark (1923) reported the case of a woman, aged forty-two years, who, in the course of one and a half years, had been exposed to five erythema doses of roentgen rays for excessive growth of hair around the mouth, each treatment being directed to four fields: each side of the chin, the upper lip, and the lower lip. The skin appeared to tolerate the exposures at the time, but one and a half years later necrosis of the middle portion of the alveolar process of the lower jaw occurred. Resection of a portion of the bone was followed by infection and a fistula. When the excised piece of bone was examined microscopically, evidence of necrosis could not be found. Blum (1924) mentioned a case of osteomyelitis of the mandible, somewhat similar to necrosis from phosphorus, which had been caused by some radio-active substance in paint used to render watch dials luminous.

Hoffman (1925) reported four fatal cases of necrosis of the mandible complicated by severe anemia and caused by radioactive substance introduced into the mouth by the brush used to apply so-called radium paint, composed of zinc sulphide, radium, and mesothorium, to the figures of watch dials. He also recorded eight other cases of similar necrosis, but only one with anemia. The patients, all of whom were still living, had been employed in the same factory. Sochoky (quoted by Hoffman) described the conditions of employment which had given rise to such lesions, which he justly attributed to the alpha rays and to the zinc sulphide collecting at one point on the mucosa and acting for a long time. Martland, Conlon, and Knef (1925) published an exhaustive report on the working conditions which gave rise to such disturbances. They also reported three cases. In one, the patient died with necrosis of the alveolar border of the mandible, ulceration and in-

fection of the soft tissues—including the soft palate—severe anemia, and toxemia. At necropsy, all the organs and bones tested with an electrometer were found to contain an appreciable quantity of radio-active matter. The second patient, who had progressive necrosis of the lower jaw and chronic, pernicious, leukopenic anemia, still lived. In the third patient slight necrosis of the jaw developed, but this healed. The expired air of the two last patients was found to contain a measurable quantity of radio-active substance.

Phemister (1926) reported four cases of sarcoma, in each of which from four to eight needles, each containing 12.5 mg. of radium, had been left in contact with bone in an aseptic field for from fifteen to twenty hours. Frequent roentgenograms were made during the ensuing twenty-two, forty-six, twenty-three, and two months, respectively. Distinct necrosis of bone was found, but the devitalized bone did not become detached as a sequestrum. In the second case, in which the course of events was watched over a period of forty-six months, the structural changes in the bone indicated replacement of the dead bone by new bone.

Ewing (1926) described three examples of radiation-osteitis. In one patient, a boy, aged sixteen years, a radium pack had been applied to the leg nine times in three months for endothelial myeloma of the tibia. Subsequently, radiodermatitis and recurring attacks of pain developed, and the leg was amputated one and a half years later. The bone was found to contain active tumor tissue, and the shaft was thickened at the expense of the marrow cavity. Microscopic inspection revealed viable tumor cells and zones of necrosis encased in dense fibrous tissue. The second patient had a giant-cell tumor of the distal end of the femur. After curettage of the growth a radium pack had been applied fifteen times; this led to necrosis of the skin and chronic osteitis which necessitated amputation. The third patient had an osteogenic sarcoma of the lower end of the femur, for which the part had been exposed to roentgen rays of short wave length eleven times in four months. Spontaneous fracture occurred later, and the extremity had to be amputated. The tumor was found largely destroyed, but the adjacent normal portion of the shaft was devitalized and callus was absent. Ewing thought the rays acted chiefly on the bone cells rather than on the lamellæ of the bones. Rahm (1927) described one case of necrosis of the body of the left half of the lower jaw resulting from irradiation following an operation for epithelioma of the lower lip. The patient had received four courses of treatment at intervals of one or two months; the rays had been made to converge toward the region through three separate fields. The patient had been given another course of irradiation six months later, and two additional courses within four months. Edema and induration of the chin appeared two years later, and, on further irradiation, the face swelled, a high fever developed, an abscess formed and broke, and a fistula communicating with bone persisted. A roentgenologic examination disclosed osteomyelitis, and a histologic examination showed inflammatory tissue.

Hueck and Spiess (1929) analyzed a series of seventy-six cases of tuberculosis of bones and joints in patients less than twenty years of age, who had been exposed to therapeutic irradiation. Fifteen did not show any noticeable disturbance of growth, but in sixty others definite inhibition of development was found. An apparent increase in growth was noted in only one case. The retardation in growth was attributed to the action of the tuberculous process on the epiphyses and to the inactivity of the patients and not to the roentgen rays.

St. George, Gettler, and Muller (1929) reported having exhumed, five years after her death, the body of a young woman, aged



Fig. 1. The right humerus March 23, 1924, showing tumor involving the upper third of the bone, with spontaneous fracture.



Fig. 2. The right humerus May 22, 1924, showing diminution in size of the tumor and increased density in the bone indicating repair.



Fig. 3. The right humerus in abducted position October 20, 1924, showing further reduction in the size of the tumor and more advanced repair of the bone.

twenty-five years, who had previously worked for four years as a painter of luminous watch dials. Necrosis was found in the inferior maxilla, part of which was absent, and, also, in the superior maxilla. All the organs and bones tested gave electroscopic and photographic evidence of radio-activity. They mentioned another case of supposed necrosis of bone, but the diagnosis rested only on clinical and roentgenologic data. Finally, Martland and Humphries (1929) mentioned that, in fifteen patients whose death was attributed to radium mesothorium poisoning incurred while they were employed in applying luminous paint to watch dials, radiation-osteitis, especially in the weight-bearing bones, was found, and in two osteogenic sarcoma had developed. The diagnosis in one case was based on the histologic appearance of the tumor found at necropsy, but in the other case only on clinical data.

I should like to supplement the foregoing evidence that sufficient doses of roentgen or radium rays may cause serious injury to bone by recording the following case.

A girl, aged nine years, registered at The Mayo Clinic, March 3, 1924, complaining of swelling of the right arm. In November, 1923, the child had injured the arm, had swelled and become painful, but the parents had not paid any particular attention to this until December, when a roentgenologic examination of the right humerus had led to a diagnosis of tuberculosis or sarcoma. After the Holidays the swelling of the right arm had been stationary and the pain had disappeared, except when the upper portion of the arm had come in contact with other objects. The child had had a tendency to avoid using the extremity. Her previous history had been entirely negative. January 23, 1924, a specimen had been removed elsewhere, and the pathologist who examined the tissue had pronounced it small-cell sarcoma.

A general clinical examination and roentgenograms of the right humerus led to confirmation of the diagnosis of small-cell sarcoma of the upper third of the right humerus (Fig. 1). Moreover, microscopic examination of a section of the specimen previously removed revealed osteogenic sarcoma. Inspection of the roentgenograms showed that the tumor was complicated by spontaneous fracture of the bone. It was probably this fracture which had given rise to the swelling and pain which had caused the parents to have the child examined.

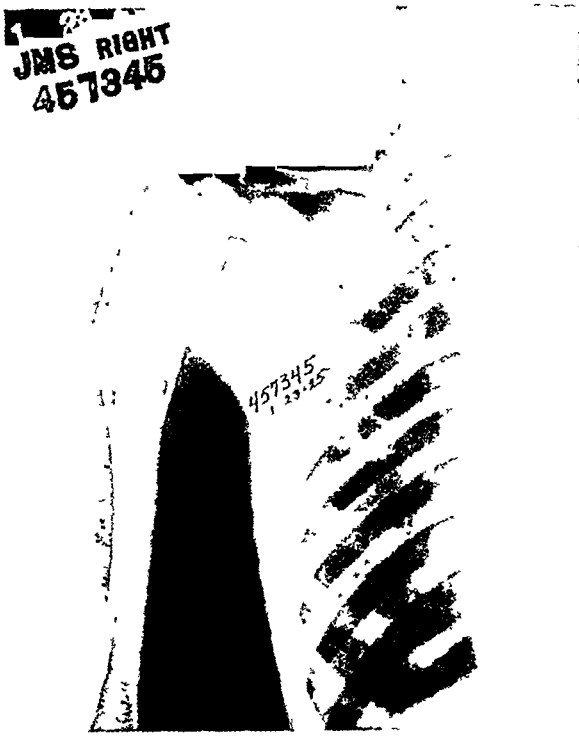


Fig. 4 The right humerus January 23, 1925, showing continued regression of the tumor and progressive repair of the bone.



Fig. 5. The right humerus June 4, 1925, showing marked regression in the tumor and advanced repair of the bone.

treatment which gave any hope was either amputation of the right upper extremity at the shoulder or treatment by roentgen rays, they decided to try the latter. Before this was done, however, it was carefully explained to them that the treatment by roentgen rays would have to be thorough and systematic and that, in all probability, this would inhibit the growth of the irradiated bone and surrounding structures. On the parents' assurance that, in their anxiety to save the child's life, they were prepared to accept the risk, a course of roentgen-ray treatment was given between March 19 and 24, 1924, through seven separate fields The beam of rays in each case was concentrated on the upper half of the right humerus and shoulder.

When the child returned, April 21, 1924, the skin over the upper part of the right arm and shoulder was faintly pigmented; otherwise, the child's condition was about the same as before. A second course of treatment with rays generated at moderate voltage was given between April 22 and 24; the distribution of such treatment was precisely the same as in the first instance. The child returned, May 21, in good general condition. All pain in the right arm had subsided, but the arm was still slightly larger than the left arm at the same level. A roentgenogram of the right humerus, made May 22, showed apparent improvement in the condition of the bone (Fig. 2). A third course of treatment with roentgen rays generated at moderate voltage was given May 22 and 23 through four fields only. The child was next seen July 21, 1924, when the parents reported that she tried to use the arm more than previously. Examination showed the tumefaction in the right arm to have diminished considerably. July 22 and 23, 1924, a fourth and last course of treatment with roentgen rays of short wave length was given. Following this the condition of the arm improved steadily and a roentgenogram, made October 20, 1924, showed considerable increase

in the density of the bone at the site of the tumor and reduction in the circumference of the arm at this level (Fig. 3). At the time it was uncertain whether such reduction in size was due to regression of the tumor or to atrophy from disuse. The child's weight increased normally and she used the right arm more and more freely. The next roentgenographic examination was made January 23, 1925 (Fig. 4). This disclosed continued regression of the tumor and further increase in the density of the bone. The child was still unable to raise the arm above the level of the shoulder. By June 4, 1925, the skin over the upper half of the right arm and right shoulder showed slight telangiectasis. The parents reported that, since her previous examination, the child had had six attacks characterized by severe headache, associated with nausea, vomiting, and sometimes fever. The fever had disappeared after the headaches had subsided. This gave rise to a suspicion of cerebral metastasis, but the presence of fever was puzzling because, in spite of careful investigation, it could not be clearly explained. A roentgenographic examination of the right humerus, June 4, 1925, showed a steady increase in the density of the bone, without evidence of malignant activity (Fig. 5).



Fig. 6. Appearance of the child November 22, 1926, showing interference with the growth of the right arm and right shoulder, both as to bones and muscles, and also the telangiectasis of the skin.

When the child returned, February 25, 1926, the parents reported that the attacks of headache, which she had had previously, had not recurred since June, 1925. On examination, obvious asymmetry of the two shoulders and of the upper portion of the two upper extremities indicated inhibition of growth, not only in the right humerus, but also in the muscles around the right shoulder. Telangiectasis of the skin had increased. So far as the tumor in the humerus was concerned, no evidence of malignant activity, but rather clear evidence of continued repair, was found. In November, 1926, retardation of growth of the right arm and atrophy of the muscles around the right shoulder were still more



Fig. 7. The right humerus November 22, 1926, showing still greater regression of the tumor and more advanced repair of the bone, but such repair is not tending to restore the normal textural lines This probably indicates that the reparative process has been modified by the action of the rays



Fig. 8 The right humerus June 14, 1929, showing arrest of tumor and continued abnormal repair of the bone.

evident, as the corresponding parts on the opposite side had continued to grow at a normal rate (Fig. 6). The child was otherwise healthy and her mother said that she was becoming more and more active. The condition of the upper third of the right humerus had improved steadily, but a roentgenographic examination, November 22, 1926, made it clear that the reparative process in the bone was peculiar in that the depo ition of new bone did not seem to be taking place in such a way as to give it a normal appearance. Even then it appeared probable that the reparative process had been modified by irradiation, which undoubtedly had destroyed many bone cells and thus led to abnormal repair (Fig. 7). When the child was seen again, in December, 1927, the condition of the right humerus was still improving and there was no evidence of malignant activity. The difference in growth between the right and left upper extremities and the muscular atrophy around the right shoulder were still greater. Up to this time the parents had been advised to prevent the child from using the right arm too much, but they were now advised to allow her to exercise the arm more freely.

Another examination in June, 1928, showed that the condition of the right humerus had continued to improve, and the child's mother reported that she had been active during the previous school year. The improvement in the condition of the right humerus and in the general health of the child continued steadily. She gradually increased her physical activities and even undertook swimming and tennis, in spite of the muscular atrophy. When she was examined, in June, 1929, her condition was satisfactory in every way (Fig. 8).

COMMENT

This case is interesting in that it shows clearly that irradiation of the rapidly grow-

ing bone of a nine-year-old child can retard its growth or permanently injure it according to the total dose of irradiation, but it also shows that the growth of the muscles and other structures irradiated may also be greatly impeded. Besides this, it is clear that while irradiation has caused the malignant tumor in the bone to retrogress, and although such retrogression appears to be complete, yet the reparative efforts of the bone have been modified considerably by irradiation.

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DISCUSSION

DR. FRANCIS CARTER WOOD (New York City): I can add cases that are similar to those recorded by Dr. Desjardins. For example, a boy of about eight years of age, who developed a Kaposi sarcoma on the forearm, was given heavy radiation. The boy, now about fourteen, is apparently well, but his left arm, the site of the radiation, is shrunken, the bones are shorter and smaller, and the muscles of the forearm are distinctly atrophied. I have assumed that the radiation of the epiphyses has checked the normal bone growth.

DR. A. U. DESJARDINS (closing): I did not report this case with the idea of scaring any one from treating bone tumors—quite

the contrary; but it was important to bring to the attention of every one the possibility of retardation of growth and to make this better known than it now seems to be. Another point which I might mention in this connection is that many bone tumors, regardless of their character, are being treated in much the same way, and this also is a bad thing. The fact that growth can be retarded should make us more careful to this extent, that we should individualize varieties of bone tumors and give each variety a dose sufficient to deal with it without going too far. For instance, giant-cell tumors require only small doses of rays of medium wave length —it is easy to over-treat such a tumor and obtain inferior results; whereas, if it is not over-treated, excellent results may be obtained. With osteogenic tumors, on the other hand, we must take no chances and treat them with less regard for other factors. If the possibility of retarded growth is understood and the parents informed beforehand, they generally will accept the risk. They will usually accept such risk even if they are not told beforehand, but they may seriously object later if they have not been told.

TREATMENT OF MALIGNANT TUMORS OF THE EYE AND ORBIT BY RADIATION

By FREDERICK HASE RODENBAUGH, M.D., San Francisco

THE tissues of the eye and adnexa are of such variety in origin and structure that almost every known type of tumor has been found in these parts, either primary, through direct extension, or metastatic. In this survey are summarized those types which have been treated with radiotherapy, the results being compared with other methods of treatment as to conservation of normal tissue and permanency of cure. Obviously, many types of tumors have not received radiation therapy because of well-established surgical procedures, with favorable end-results, and in instances in which conservative methods are of little importance; for example, pigmented tumors of the choroid, with loss of vision from the tumor and rare local recurrence.

There are essential technical differences in the use of radiotherapy in malignant growths of the eye or orbit, as compared with other structures of the body in which these agents are in widespread use. The problem of dosage is most important. Radiotherapy, in the average case of neoplasm, is not conservative, and a maximum amount of fibrosis in the surrounding tissues is not harmful, but the reverse is true in lesions of the eye. Here a maximum conservation of normal tissue is essential. The lesions are, as a rule, well localized, and extreme conservation of the normal structures is of paramount importance.

The ophthalmologist and the radiologist have, of necessity, had a limited experience in these cases, with few opportunities to study the comparative effect of various combinations of radiotherapy with variable intensities and dosage, because of the comparative rarity of such lesions.

A general consideration of the physical factors in the treatment of this group would seem to indicate that there is a place for all variations of radiotherapy—the use of unfiltered radium or X-ray for superficial intense reactions and heavily filtered radium or X-ray for deep-seated lesions, the choice of agent being dependent on the extent and location of the lesion.

The agent of first choice, in our opinion, is radium, because of the ease of application and accuracy in measurement of dosage.

In corneal, scleral, and superficial lesions of the lids the technic, in general, is as follows: The use of from 25 to 50 mg. of unfiltered radium to produce an intense, superficial reaction, with a minimum depth dose. Such a technic assures a maximum conservation of normal tissue, and the applicators can be held in position and observed during treatment, two to ten minutes being the average dose.

In the more deep-seated growths, heavily filtered local or general orbital radiation is used and can be given with X-ray or radium. The choice of agent is not so important, but radium has been our personal preference for the smaller lesions.

The biological effects are apparently the same with X-ray or radium, the choice of agent depending on physical factors rather than biological. There is, however, some evidence to indicate that the end-results of some reported failures might have been improved with the use of divided doses to saturation, allowing sufficient time for regression before continuing treatment. With this technic the reaction is reduced to a minimum. The therapeutic response of similar neoplasms, so treated in other parts of the

body, is encouraging, and similar methods can be used to advantage on the structures in the orbit.

The control of radiation reactions of a neoplasm in the structures of the eye—cells undergoing involution from radiation—as pointed out by Poleff (1), can be observed by the ophthalmologist with instruments of precision, and offers a fertile field for investigation of the minute microscopic changes occurring in life. This is best demonstrated in the cornea by frequent observations of the changes in carcinoma cells following radiation treatment. No other structures permit this observation of human carcinoma cells *in vivo,* and such observations obviate the necessity for massive doses to large areas, when individual masses of cells may be treated as units.

The structures of the orbit for this survey may be roughly divided into three groups: (1) Epibulbar group, comprising the cornea, sclera, and ocular conjunctiva; (2) intra-ocular group; (3) the adnexa, including the lids, conjunctiva, and lacrimal glands.

EPIBULBAR TUMORS

In the first group (epibulbar tumors), the most common malignant tumor of the conjunctiva is the epithelioma, which most often takes its origin at the limbus. As elsewhere in the body, it is most common where types of epithelium change, or as part of a constitutional disease such as xeroderma pigmentosum. It is usually of a basal or mixed basal and squamous cell type, tending to slow erosion through the sclera, causing local destruction but seldom metastasizing. The growth, however, may occur on any part of the conjunctiva though rarely on the cornea, and tends to grow in the path of least resistance, outwards, assuming polypoid forms. The invasion of the sclera is, as a rule, late in the disease, and such tumors yield the most brilliant results to radiotherapy. They are ideally adapted to intense, sharply localized radium reactions with a minimum depth dose, as illustrated by Case No. 1, and should receive radiation as a primary therapeutic agent.

Case No. 1. Mr. M., age 62 years. Had enucleation of right eye many years previous to present examination, following injury. The duration of the lesion on the left eye is indefinite. The growth on the cornea had been present for several months, with gradual increase in size, until the patient consulted a physician because of irritation and inability to close the lids. Examination showed a papillomatous growth involving the outer half of the cornea, the center of the mass over the corneoscleral junction. The growth was irregular in shape, about 2 cm. in diameter and 1 cm. thick, the inferior border being thicker than the other portions of the tumor.

Treatment: Tumor divided into five areas to permit even distribution of radiation, the areas being determined by relative thickness of tumor.

Technic: Twenty-five mg. of radium sulphate in a glass tube, no filtration, held in place, the position of the tube observed during treatment. Exposure time: five to ten minutes to each area, varied as to the thickness of the tumor. This dose previously had been calculated by experiment for an intense superficial reaction. The entire field was covered at the first treatment (five areas); subsequent treatments in ten days. The progress of the treatment was observed under magnification and subsequent treatment was based on the appearance of cellular reaction. The clinical course showed a slight reaction from treatment, no ulceration; complete regression occurred in two months. Two years later, the patient was clinically well.

This case illustrates the relatively small amount of radium necessary to produce involution of carcinoma cells with a minimum amount of fibrosis in adjacent structures, a



Fig. 1-*A*. Case No. 1. Carcinoma of conjunctiva at limbus; average type.



Fig. 1-*B*. Same case, showing results of intense unfiltered radium therapy in divided doses. Photograph taken two years after Figure 1-*A*.

most essential point in this case because of the previous accident to the right eye.

Sarcoma of the conjunctiva is uncommon and has no predilection for any special type. The pigmented form will be discussed later. In the cornea, sarcoma has been treated with successful results by the use of radium, analogous to the response of sarcoma to radiation therapy in other structures, and is illustrated by Case No. 2, using intense localized unfiltered radium with a minimum depth dose.

Case No. 2. D. G., Chinese, age 59 years. Duration of the lesion was approximately six months, though the patient was not definite as to the exact time of its appearance. He consulted an ophthalmologist when vision was impaired. The present examination shows a smooth, elevated, white neoplasm about 10 mm. in diameter and 5 mm. thick, on the inner half of the left cornea, with a superficial invasion of the cornea. The borders of the growth are smooth.

Diagnosis: Sarcoma.

Treatment: The lesion was divided into three areas, to permit of even distribution of the radiation, using 25 mg. of unfiltered radium, held in position during treatment. The center of the mass received nine minutes on the first treatment, eight subsequent treatments of five minutes each over various areas of the most active remaining portion of the tumor, the area to be treated being selected after observation under magnification.

Ten months later the lesion had entirely disappeared, without a scar. Four years later there had been no recurrence.

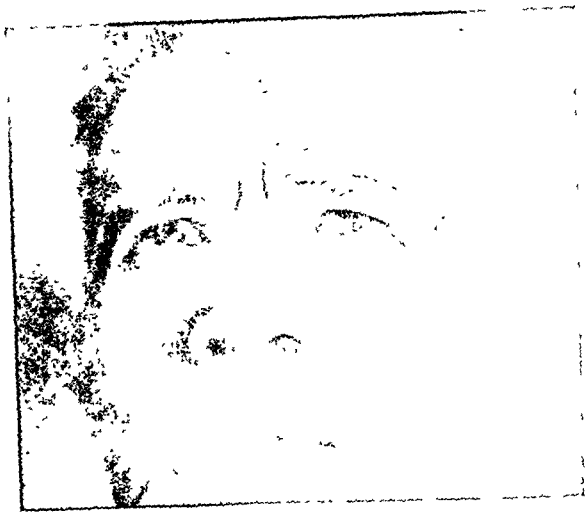


Fig. 2-*A*. Case No. 2. Sarcoma of cornea.



Fig. 2-*B*. Same case, showing results of intense unfiltered radium therapy in divided doses. Photograph taken two years after Figure 2-*A*.

Case No. 2 illustrates the results of divided dosage over a long period, with maximum conservation of tissue.

Melanosis oculi is a congenital condition, marked by focal or diffuse excessive pigmentation of choroid, iris, or conjunctiva, the ocular counterpart of the cutaneous nevus. Pigmented spots may also appear in the eyelids and over the skin of the face. Doherty (7) finds that 29 per cent of the cases eventually develop malignant melanoma.

In the conjunctiva, pigment spots appear at birth or later and may remain unchanged throughout life or become the source of malignant tumors. Parsons describes them as of epithelial origin, reproducing the picture of cutaneous pigmented moles. There are epithelial hyperplasias, shallow extensions into the deeper tissues, and the appearance of chromatophores. The lesions may gradually extend over the conjunctiva and eyelid, and, when incompletely removed, may be followed by the usual widespread dissemination through the blood vessels. Ewing has followed one congenital case for ten years, which gradually extended, was twice excised, and eventually became disseminated. Case No. 3 illustrates the type of response of the plaques of pigmented tumors on the conjunctiva and cornea to radium, with intense unfiltered radium therapy, followed by regression of the growths.

Case No. 3. H., age 64 years. The past history reveals that thirty years ago the patient first noticed pigmentation in the right eye, probably on the conjunctiva. For the past fifteen years he has noticed steady increase in the pigmentation of the scleral conjunctiva, until two years ago when a marked increase took place, with invasion of the cornea and formation of the nevi of the conjunctiva on both lids.

Examination showed multiple nevi on both lids, with patchy pigmentation of the ocular conjunctiva. There was an irregular, superficial infiltration of the upper layers of the cornea on the superior border, the growth being smooth and slightly elevated, with considerable pigmentation. Surgical removal and histological examination of the larger nevi of the lids showed melanotic sarcoma.

Unfiltered radium treatment was used on the superficial flat pigmented plaques on the lids, with prompt involution of the growth. Eleven areas of pigmentation on the lids and conjunctiva were treated over a period of

three years. At the present time there is a small area of pigmentation on the scleral conjunctiva which has developed recently.

The most interesting phase of this case—the conjunctival growths and the corneal infiltration—responded to one treatment of unfiltered radium, with complete regression of the infiltration in three months and restoration of vision. There were a few recurrences, but in this instance they responded quickly to treatment. Conservation of vision was most important to this patient, as there is marked impairment of vision in the other eye.

This case further illustrates the prompt response to an intense radium reaction locally applied to the tumor, with minimum damage to the normal cells. However, such cases should be kept under observation and the recurrences promptly treated.

Other varieties of malignant tumors comprise angiofibroma, hemangioma, lymphoma, and lymphangioma, and are susceptible to treatment by radiation therapy with proper technic, the results being comparable to the response to treatment of similar lesions in other structures.

Of the benign and borderline types, the fibroma, papilloma, granuloma, and nevus, owing to their histological structure, have been treated with radiation therapy with success, the technic and dosage depending on the size and location of the growth. Case No. 4 illustrates results of radium therapy in a severe type of granuloma.

Case No. 4. B. L., age 6 years. Multiple granulomas of the conjunctiva. Three previous operations for removal have been followed by prompt recurrence. The present examination shows multiple large pedunculated masses at the outer and the inner canthus of the left eye. *Treatment:* Twenty-five mg. unfiltered radium, held in position at the base of granuloma for four minutes. No recurrence of growths three years later.

INTRA-OCULAR TUMORS

In the second group (intra-ocular tumors), the most frequent and malignant are the melanomas or melanosarcomas, which have a variety of histological forms but a uniformly high degree of malignancy. They occur in the choroid, iris, and ciliary body. The response of this group to radiation has varied. In general, they have been most resistant, and the number of cases of primary lesions receiving treatment has been limited. The high percentage of primary cures following surgical removal (60–80 per cent), and the infrequent local recurrence, in most instances has precluded the use of radiation therapy. Conservative treatments are of only relative importance, as these growths have usually already destroyed vision when seen by the radiologist.

There are, however, cases of local tumors of the iris and ciliary body that, clinically, resemble the non-pigmented form of sarcoma. These have responded to radiation without recurrence of the lesion. One such case has been observed by the writer after a five-year period, but the diagnosis is, of course, questionable, because histological studies are not possible when conservative treatment is used.

Two similar pigmented lesions of the iris have shown no response to radiation therapy in average doses. Large doses are not indicated, as there is definite evidence to show that massive radiation produces permanent changes in the lens, and such changes would not increase the functional results as compared with surgical methods.

Glioma of the retina is a rare type of specific tumor growth and is favorably influenced by radiation, but the regression is usually only temporary.

A summary of the effects of radiation on intra-ocular tumors leaves much to be desired, but the disappearance of tumors of the iris and ciliary body, of doubtful nature, should indicate that such tumors be radiated

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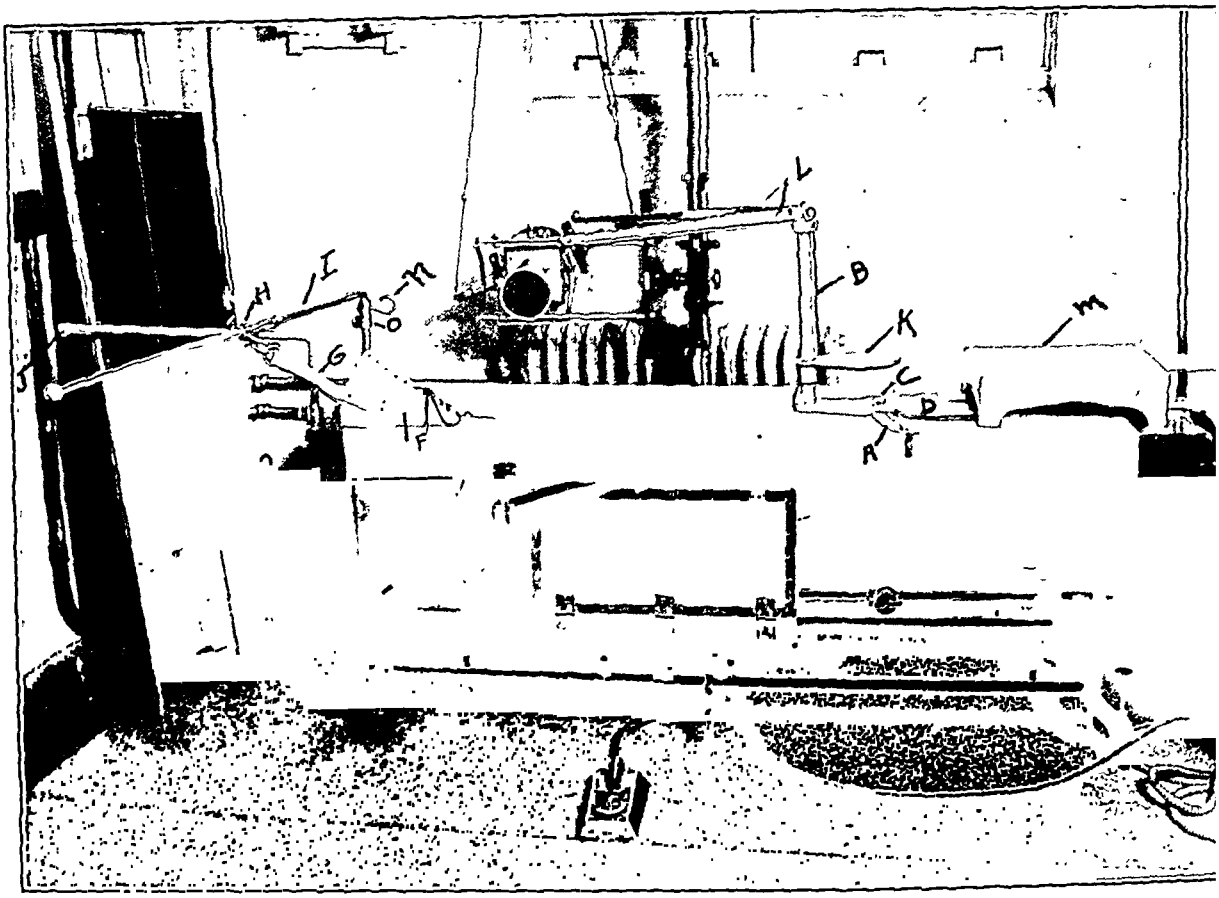


Fig. 1. Device for the reduction of fractures with key to references. (A) Arcuate track along which base "D" slide (B) Center peg for crotch or axilla. (C) Set screw which fixes "D" at any place along track. (D) Base (lengthened s as not to obscure hip and shoulder fractures). (E) Socket at head of table into which "D" fits. (F) Cuff for wrist or ankl (G) Straps. (H) Hook with setscrew which slides along lever "I." (I) Traction bar. (J) Lever to hold extensio (K) Pelvic support. (L) Levers for suspension of lower extremities in the application of casts. (M) Back and head res (N) Hook to which normal extremity is attached to prevent rotation on crotch peg. (O) Collar to adjust height of norm extremity.

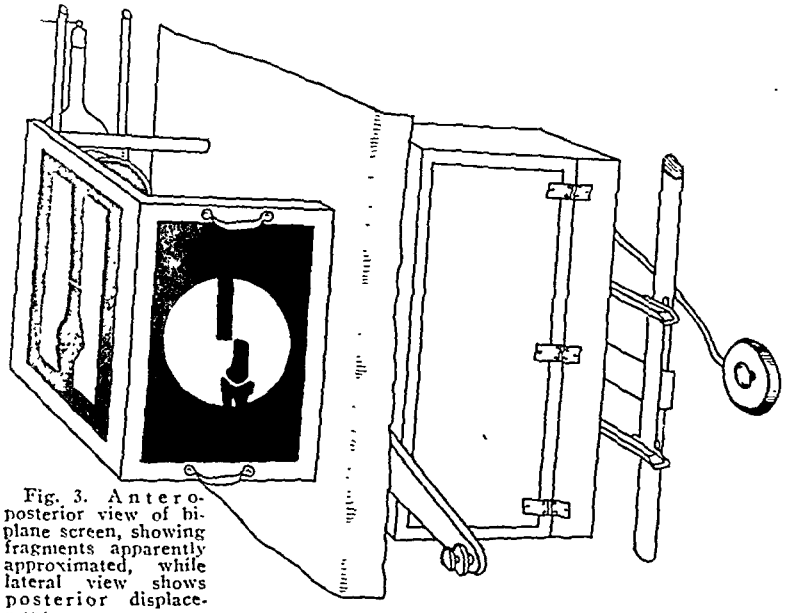


Fig. 3. Antero-posterior view of bi-plane screen, showing fragments apparently approximated, while lateral view shows posterior displacement.

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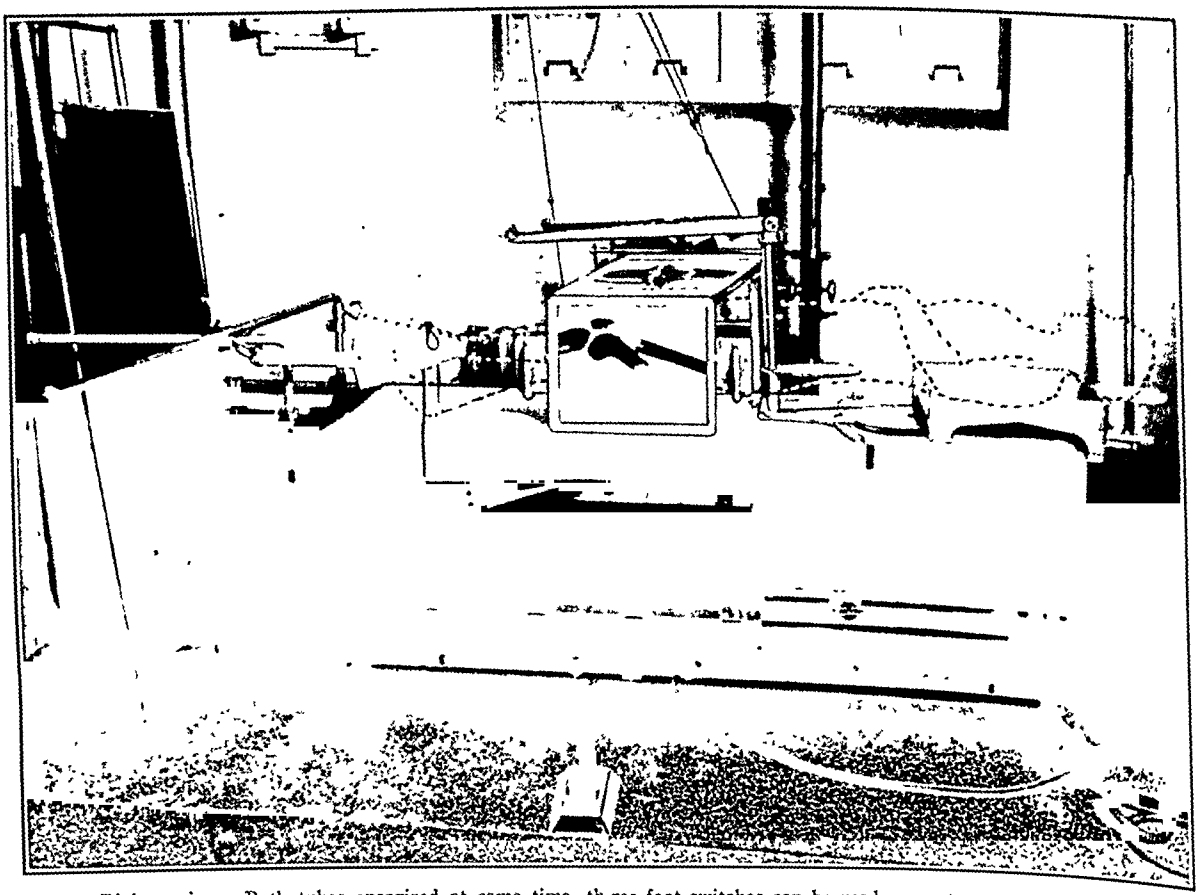


Fig. 3. Biplane view. Both tubes energized at same time, three foot switches can be used:—one to control tube above table, one for the tube below, and one for energizing both tubes at the same time. Traction is made by lever while under fluoroscopic vision. This is an ideal arrangement, for the reduction of fractures and the removal of foreign bodies, when the biplane fluoroscopic screen is used in conjunction with shock-proof X-ray apparatus.

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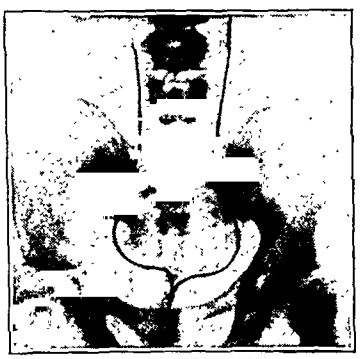
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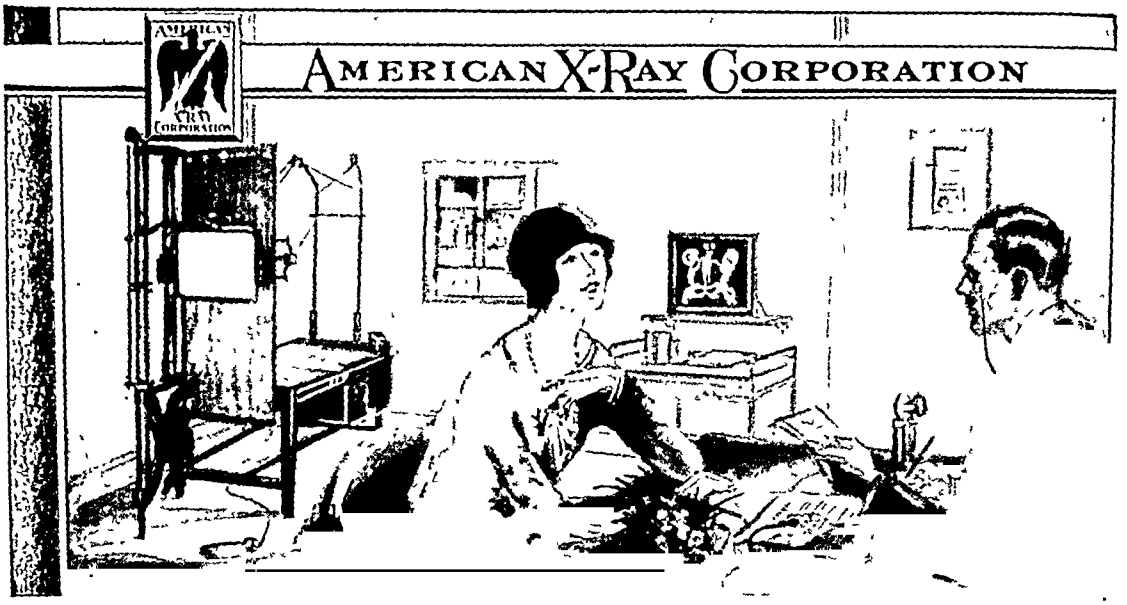
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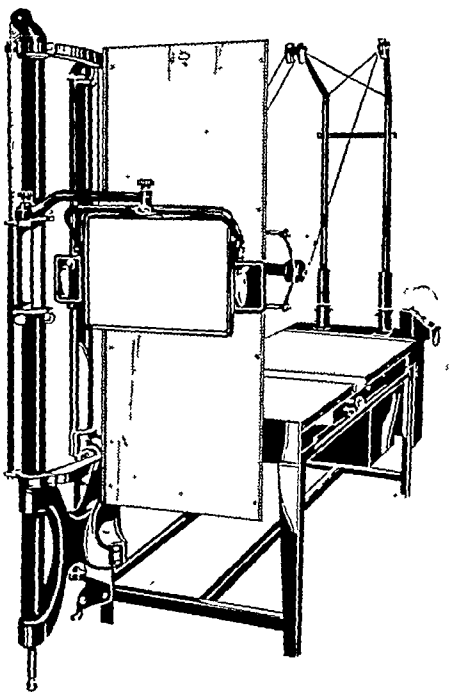
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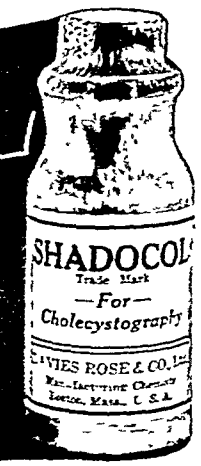
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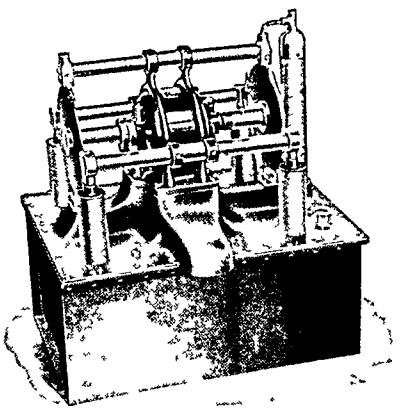
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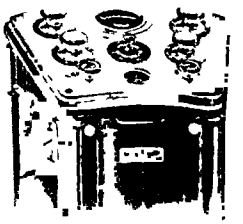
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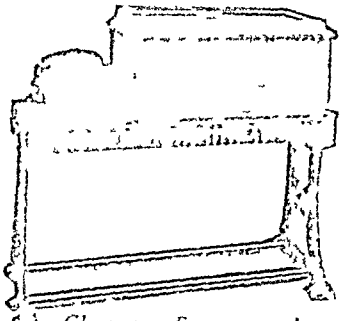
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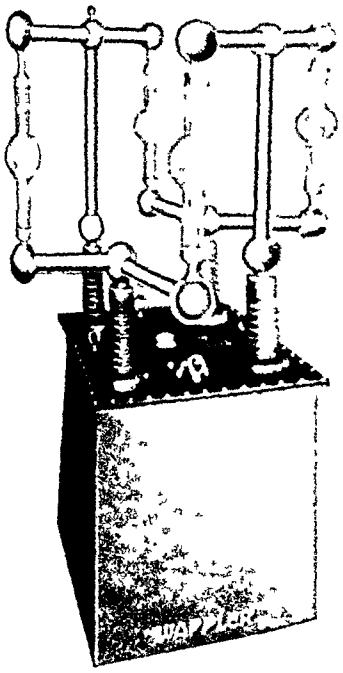
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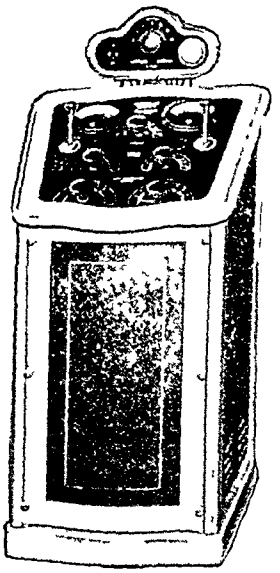
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